Chemistry 4
Organic Chemistry 1

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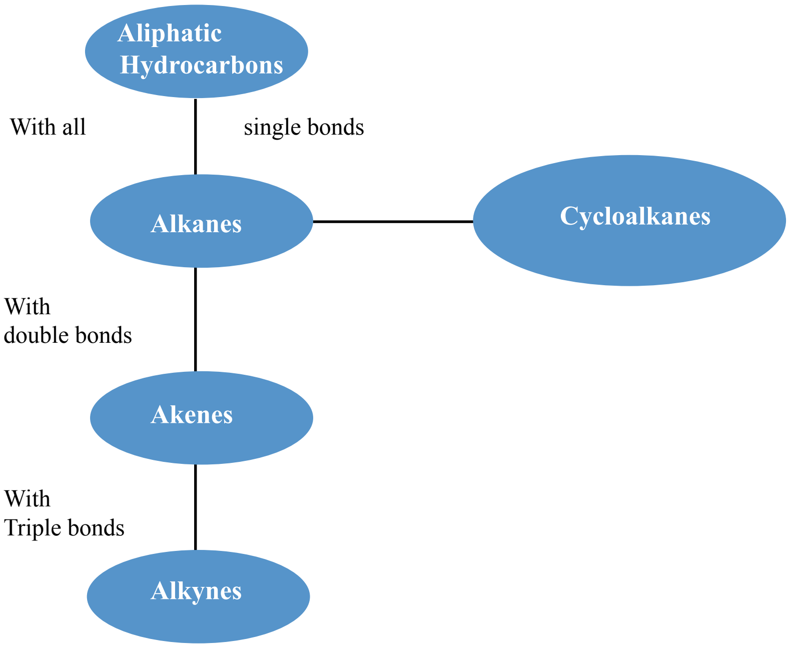
I. Chemistry 4, Organic Chemistry 1

Prepared by Dr. George L. Mhehe and Mahamud Mohamed Korane

Aliphatic Organic compounds and their interrelated functional groups



II. Prerequisite Courses or Knowledge

Chemistry I Course: Atomic structure and Bonging, and Chemical reactions And Chemistry II Course: Chemicaal Kinetics, Thermodynamics and solution Chemistry

Chemistry I course is a general introductory chemistry course, it has important aspects that are needed to undestand the organic chemistry in this module. The knowledge on bonding, the difference between ionic and covalent bonding, electronic configuration of different atoms; all these aspects are vital for a good understanding of this module on organic chemistry . Chemistry II course is even a more relevant prerequisite for this module because it had a unit on introductory organic chemistry where at the end of that particular unit of that module you were expected to be able to

- classify types of organic compounds based on functional groups
- name different classes of organic compounds using the International Union of Pure and Applied Chemistry (IUPAC) system of nomenclature
- write structural formulas of different isomeric compounds
- relate properties and reactions of organic compounds to functional groups.

III. Time

To cover this model will require about 120 hours distributed as follows

Unit I:	20 hrs
Unit II:	20 hrs
Unit III:	20 hrs
Unit IV:	20hrs
Unit V:	20hrs
Unit VI:	20hrs

IV. Material

The following Tools and resources are important materials that will be necessary to learn this module:

Models of structures of Aliphatic hydrocarns on CD-ROMs
Internet-based as a references of the learners
Computer aided instruction (CAI)
Computer-based assessment (CBA)

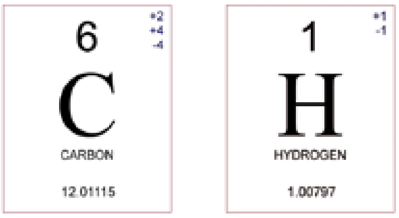
Multimedia delivery (including video conferencing)
e-Library and data base utilization
Integrated learning environment
Interactive discussions/chat sessions
Recommended textbooks and reference(including web pages) materials

V. Module Rationale

This module in organic chemistry is designed to prepare students that wish to become teachers : Student teachers must have knowledge of the key concepts and classification tools of organic chemistry that include functional groups of hydrocarbons,alcohols and ethers,aldehydes and ketones,alkyl halides,carboxycylic acids and their derivatives and amines.Classes of organic compounds can be distinguished according to functional groups they contain.

Organic compounds are now defined as compounds that are based on carbon. So the branch of chemistry that deals with carbon compounds is organic chemistry. They usually contain carbon-carbon and carbon hydrogen bonds.

Carbon`s unique bonding properties allow the formation of a variety of structures, including chains and rings of many shapes and sizes.



VI. Content

6.1 Overview

This module is the branch of chemistry that deals with carbon compounds and it is called organic chemistry.

This module is about classes of organic compounds that can be distinguished according to functional groups they contain.

In this module you will be learning the characteristic properties of a number of functional groups. Thus by studying the characteristic properties of a few of these functional groups,you will be able to understand the properties of many organic compounds.

In this module we will have functional groups of hydrocarbons,alcohols and ethers,aldehydes and ketones, alkyl halides,carbocyclic acids and their derivatives, and amines.

6.2 Outline

The following is the outline of the content of this module.

Unit I –Hydrocarbons

Aliphatic hydrocarbons
Physical and Chemical properties of hydrocarbons.

Unit II-Alcohols and Ethers

Chemistry of the functional group.
physical and chemical properties and reactions of alcohols and ethers
Synthesis of alcohols and ethers

Unit III -Aldehydes and ketones

The structure of aldehydes and ketones
Physical properties of aldehydes and ketones
Aldehydes and ketones using the IUPAC system of nomenclaure
Typical reactions of aldehydes and ketones
Synthesis of aldehyde and ketones

Unit IV -Alkly halides

The different categories of alkly halides
Nomenclature of alkly halides using the IUPAC system
Physical and Chemical properties of alkyl halides
Typical reactions of alkly halides
Preparation of alkly halides

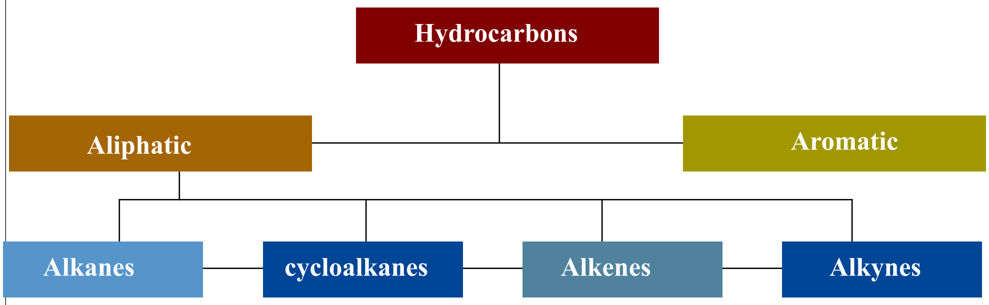
Unit V-Carboxylic acids and their deivatives

Structure of carboxylic acids and their derivatives
IUPAC nomenclature carboxylic acidsof and their derivatives

Unit VI -Amines

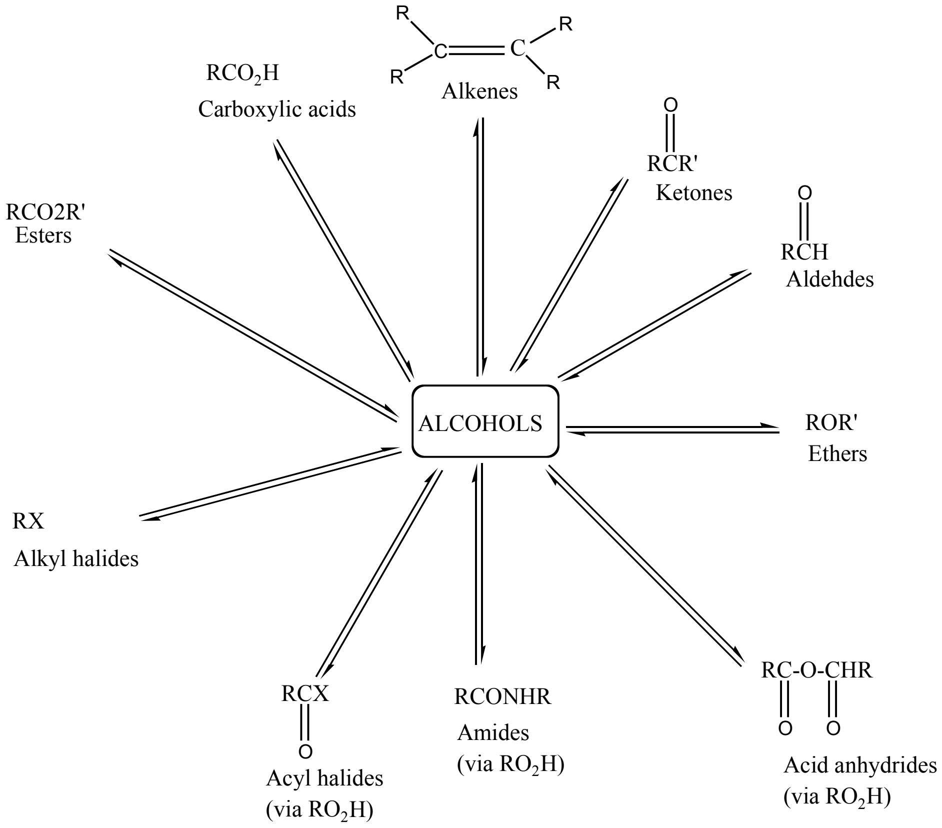
Different categories of amines
The general structure of amines
Naming amines using the IUPAC nomenclature

6.3 Graphic Organizer



THE CENTRAL POSITION OF ALCOHOLS IN ORGANIC CHEMISTRY

Alcohols can be prepared from, and converted into many other kinds of compounds



VII. General Objective(s)

Aquire the vocabulary and basic theories of modern organic chemistry

- to familiarise you with the concept of aliphaticity and aliphatic compounds so that you are able to identify aliphatic compounds based on their structures.
- To understand the different types of aliphatic compounds and know how to name them using the IUPAC system of nomenclature
- Investigating and solving problems
- to help you to use ICT facilities in teaching

VIII. Specific Learning Objectives (Instructional Objectives)

Unit	**Learning objective(s)**
Unit I.Hydrocarbons	Differentiate among the different types of hydrocarbons Name saturated and unsaturated hydrocarbons Descibe and predict typical reactions of hydrocarbons Describe the physical and chemical properties of hydrocarbons
Unit II .Alcohols and Ethers	Differentiate among the various categories of alcohols Name alcohols and ethers Describe and predict typical reactions of alcohols and ethers Describe the physical and chemical properties of alcohols and ethers Describe the synthesis of alcohols and ethers
Unit III.Aldehydes and ketones	Differentiate between the structures of aldehydes and ketones Differentiate between the physical and chemical properties of aldehydes and ketones Name aldehydes and ketones by using IUPAC nomenclature system Describe and predict typical reactions of aldehydes and ketones Describe the synthesis of aldehydes and ketones

Unit IV.Alkly halides	Differentiate among the different categories of alkyl halides Name the alkly halides by using IUPAC system Describe the physical and chemical properties of alkyl halides describe and predict typical reactions of alkyl halides Give the different methods of preparation of alkyl halides
Unit V. carboxylic acids and derivatives	Identify the general structure of caboxylic acids and their derivatives Name the carboxylic acids and their deravatives using IUPAC system Describe the properties and chemical reactions of carboxylic acids and their derivatives Describe the various methods of preparations of carboxylic acids and their derivatives
Unit VI. Amines	Identify the various categories of amines Identify the general structure of amines Name amines by using IUPAC system Describe the properties and chemical reactions of amines Describe the various methods of preparations of amines

IX. Pre-assessment

Title of Pre-assessment :

Multiple choice questions to test your understanding of the concepts covered in the module

Rationale : Answering these questions effectively will be a good indication of your grasp of the subject matter covered in this module

Questions

Circle the correct answer

1. Hydrocarbons contain

A-Hydrogen and Chlorine only
B-Hydrogen and Carbon only
C-oxygen and carbon only

2. The main classes of Hydrocarbons are

A- Aliphatic and ketone
B-alkane and alkenes
C-aliphatic and aromatic

3. The general formula of Alkanes is

A-C_nH_{2n+2}
B- CnH_{2n+1}
C-C_nH_{2n}

4. The general formula of Alkenes is

A- C_{nH2n+1}
B- C_nH_{2n+2}
C-C_nH_{2n}

5. THe name 2-Ethylhexane is incorrect because

A-This is a common name rather than an IUPAC name
B-The longest chain has seven carbons rather than six carbons
C-Both answers A and B are correct

6. The general formula of Alkynes is

A- C_nH_{2n+1}
B- C_nH_{2n}
C- C_nH_{2n-2}

7. The simplest alkyne is

A-methane
B-Acetylene
C-butene

8. Aromatic hydrocarbons contain

A-one or more Benzene rings
B-one or more carbon-oxygen chains
C-none of them

9. All alcohols contain

A-halogen groups
B-Benzene group
C-hydroxyl group

10. The difference between aldehydes and ketones is

A. Aldehydes have oxygen as one of the atoms in their molecules but not ketones
B. Ketones have carbon-oxygen double bond but not aldehydes
C. none of the above

11.For the following compounds: Carboxylic acids, alcohols, and aldehydes, the most polar compond are

A - Aldehydes
B -carboxylic acids
C -alcohols

12. Amines are realated to

A-organic acids
B-Ammonia
C-none of the above

13. When isomeric butenes are hydrogenated

A - All of them give the same saturated hydrocarbon product
B Some give the same saturated hydrocarbon product
C None of the answers above is correct

14. When the terms primary, secondary and tertiary are applied to amines their meanings are not the same because

A alcohols are non-basic while amines are basic
B The classification in alcohols is based on the number of alkyl groups attached to the carbon carrying the OH group while in amines this is not based on the number of alky groups to which the amino group is attached
C None of the above is correct

ANSWER KEY

1. B
2. C
3. A
4. C
5. B
6. C
7. B
8. A
9. C
10. C
11. B
12. B
13. B
14. B

5 marks X 14 = 70 marks

Notes to the student:

If you get 6 items or more correct you can consider that you are doing fine, but if you get less than 4 items correct then you have to work very hard to pass the course.

X. Key Concepts (Glossary)

1. Hydrocarbons are the simplest organic compounds that contain carbon and hydrogen only. They may be gaseous, liquid or solids. They can be straight-chain, branched chain, or cyclic molecules. Carbon tends to form four bonds in a tetrahedral geometry. Hydrocarbon derivatives are formed when there is a substitution of a functional group at one or more of these positions.

For example

CH_3CH_3 Ethane

Examples of derivatives of ethanes are CH_3CH_2OH and CH_3CH_2Cl

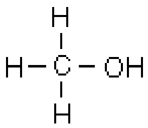
Ethanol Ethyl chloride

2. Aliphatic hydrocarbons contain carbon atoms that are bonded in one or more chains and rings. The carbon atoms have single, double and triple bonds. Aliphatic hydrocarbons include straight chain and cyclic alkanes, alkenes and alkynes
3. An alkane is a hydrocarbon that has only single bonds. Alkanes that do not contain rings have he formula C_nH_{2n+2}. An alkane in the shape of a ring is called a cycloalkane. Cycloalkanes have the formula C_nH_{2n}.
4. An alkene is a compound that has at least one double bond. A straight-chain alkene with one double bond has the formula C_nH_{2n}. The functional group for an alkene is the double bond.
5. An alkyne is a compound that has at least one triple bond. A straight-chain alkyne with one triple bond has the formula C_nH_{2n-2}. Triple bonds are even more reactive than double bonds. The functional group for an alkyne is the triple bond.
6. Alcohols : These are organic compounds that contain the hydroxyl (-OH) group as their functional group.

   Depending on the position of the hydroxyl group, An alcohol can be an primary,secondary or tertiary.

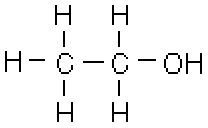
Alcohols are organic compounds containing a hydroxyl group, -OH, substituted for a hydrogen atom. The names of alcohols start with the name of the alkane but end with the suffix -ol, like the simplest alcohol, methanol.

methanol



$$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-OH$$

Ethanol is the alcohol in alcoholic beverages and it is also widely used as a solvent.

ethanol 

$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-OH$$

Alcohols can have more than one hydroxyl group. Ethylene glycol, used as antifreeze in automobiles has two OH groups.

7. Ether : is an organic compunds that has two alkyl groups joined by an oxygen atom. The general formula of an ether is R-O-R
8. Carbonyl group: is composed of carbon atoms double bonded to an oxygen C=O
9. Aldehydes: is an organic compond that has double bonded xygen on the last

O

II

cabon of a carbon chain the funcional group of an aldehyde is CH the general formula for an aldehyde is R-CHO, R- is any alkyl group.

10.Ketone: is an organic compound that has a double-bonded oxygen on any

O

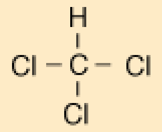
II

carbon with the carbon chain. The functional group of ketone is – C –

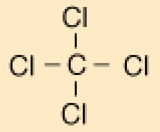
11. Alkyl halides: an alkane in which one or more hydrogen atoms have been replaced with halogen atoms
12. Aliphatic compounds: These are open chain compounds and those cyclic compounds that resemble open chain compounds
13. Aromatic compounds: These are are benzene and compounds that resemble benzene in their chemical behaviour
14. Heterocyclic compounds: These are cyclic compounds in which one or more atoms in the cyclic structure is other than carbon. Heterocyclic componds may be aliphatic or aromatic

15. Isomers: These are different compounds that have the same molecular formula. Isomers are further subdivided into:
    - (a) structural isomers,
    - (b) geometrical isomers and
    - (c) stereoisomers(optical isomers)
16. A functional group of a compound: This is the atom or group of atoms that defines the structure of a particular family of organic compounds and at the same time determines their properties

The simplest common alkyl halides are chloroform and carbon tetrachloride.



Chloroform
(trichloromethane)



Carbon tetrachloride
(tetrachloromethane)

Chloroform was used as a medical anesthetic in the past, but has been found to be carcinogenic. Carbon tetrachloride also has a long history of use in fire extinguishers, as a fabric cleaner, and as a solvent, but it causes liver damage and now is used much less.

An important class of alkyl halides is the chlorofluorocarbons (CFCs) which have been used in air conditioners, etc., as refrigerants. They face sharply curtailed use now because of danger to the ozone layer.

O

II

17. Carboxylic acid :is an oganic cmpound with the following functional groups –C-OH this –COOH group is called the carboxylic group. The general formula for carbocxylic acids is R-COOH
18. Amines: an organic compound with the functional group $–NH_2$, -NHR, or NR_2 is called an amine.

    The letter N refers to the nitrogen atom. The letter R refers to an alkyl group attached to the nitrogen. The general formula of an amine is R-$RN`_2$.

XI. Compulsory Readings

Reading #1

Complete reference: **Alcohols- From Wikipedia, the free encyclopedia**

http://en.wikipedia.org/wiki/Alcohols

Abstract : The article discusses the structure of alcohol as a derivative of of water with one of the hydrogens replaced by an alkyl group. Athe functionalgroup of alcohol is OH group.The article also gives classification of alcohols into primary, secondary and tertiary alcohols. The simplest and most commonly used alcohols are methanol (methyl alcohol) and ethanol (ethyl alcohol. IUPAC nomenclature of alcohols is also discussed. Reactions of alcohols are also discussed including diprotonation using sodium metal, nucleophilic substitution via the protonated alcohol, dehydration to give alkenes, esterification and oxidation to give aldehydes, carboxylic acids and ketones

Rationale: This ia anine page article which introduces the chemistry of alcohols very well. At the end of the article there are further links to direct the student to further readings.

Aldehyde- From Wikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Aldehydes

Abstract: An **aldehyde** is an organic compound containing a terminal carbonyl group, i.e., a O=CH- group attached to hydrogen or a carbon chain. This functional group, which consists of a carbon atom which is bonded to a hydrogen atom and double-bonded to an oxygen atom (chemical formula -CHO), is called the **aldehyde group**. The aldehyde group is also called the **formyl** or **methanyl** group.

The word *aldehyde* seems to have arisen from ***al***_cohol_ ***dehyd***_rogenated_. In the past, aldehydes were sometimes named after the corresponding alcohols, for example *vinous aldehyde* for acetaldehyde. (*Vinous* is from Latin *vinum* = wine, the traditional source of ethanol; compare *vinyl*.)

The aldehyde group is polar. Oxygen, being more electronegative, pulls the electrons in the carbon-oxygen bond towards itself, thus creating an electron deficiency at the carbon atom.

Owing to resonance stabilization of the conjugate base, an □-hydrogen in an aldehyde is more acidic than a hydrogen atom in an alkane, with a typical pKa of 17.

IUPAC names for aldehydes

IUPAC prescribes the following nomenclature for aldehydes:

1. Acyclic aliphatic aldehydes are named as derivatives of the longest carbon chain containing the aldehyde group. Thus, HCHO is named as a derivative of methane, and $CH_3CH_2CH_2CHO$ is named as a derivative of butane. The name is formed by changing the suffix *-e* of the parent alkane to *-al*, so that HCHO is named methanal, and $CH_3CH_2CH_2CHO$ is named butanal.
2. In other cases, such as when a -CHO group is attached to a ring, the suffix *-carbaldehyde* may be used. Thus, $C_6H_{11}CHO$ is known as *cyclohexanecarbaldehyde*.
3. If another functional group is present which IUPAC rules prescribe must be named as a suffix, the aldehyde group is named with the prefix *formyl-*. This prefix is preferred to *methanoyl-*. Aldehydes are also commonly recognised as alkanals, for example, methanal and ethanal are the basic aldehydes.

Rationale: The chemistry of aldehydes (and ketones) is very rich. The students is well introduced to this chemistry in this article

Ketone- From Wikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Ketone

Abstract:A **ketone** is either the functional group characterized by a carbonyl group (O=C) linked to two other carbon atoms or a chemical compound that contains this functional group. A ketone can be generally represented by the formula:

$R_1(CO)R_2$.

A carbonyl carbon bonded to two carbon atoms distinguishes ketones from carboxylic acids, aldehydes, esters, amides, and other oxygen-containing compounds. The double-bond of the carbonyl group distinguishes ketones from alcohols and ethers. The simplest ketone is acetone (also called propanone).

The carbon atom adjacent to a carbonyl group is called the α-carbon. Hydrogens attached to this carbon are called α-hydrogens. In the presence of an acid catalyst the ketone is subjected to so-called keto-enol tautomerism. The reaction with a strong base gives the corresponding enolate. A diketone is a compound containing two ketone groups.

Rationale: The chemistry of ketones (and aldehydes) is very rich. The students is well introduced to this chemistry in this article

Reading #2

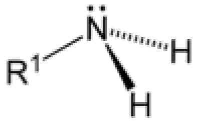
Complete reference : Amine-From Wikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Amines

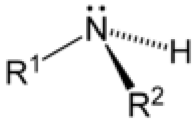
Abstract*:* Aliphatic Amines

As displayed in the images below, **primary amines** arise when one of three hydrogen atoms in ammonia is replaced by an organic substituent. **Secondary amines** have two organic substituents bound to N together with one H. In **tertiary amines** all three hydrogen atoms are replaced by organic substituents. Note: the subscripts on the **R** groups are simply used to differentiate the organic substituents . However, the number subscripts on the H atoms show how many H atoms there are in that group. It is also possible to have four alkyl substituents on the nitrogen. These compounds have a charged nitrogen center, and necessarily come with a negative counterion, so they are called quaternary ammonium salts.

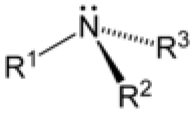
Primary amine



Secondary amine



Tertiary amine



Aromatic amines

Main article: Aromatic amines

Aromatic amines have the nitrogen atom connected to an aromatic ring as in anilines. The aromatic ring strongly decreases the basicity of the amine, depending on its substituents. Interestingly, the presence of an amine group strongly increases the reactivity of the aromatic ring, due to an electron-donating affect. One organic reaction involving aromatic amines is the Goldberg reaction

Rationale: Amines are important compounds in the dye industry in the manufacture of azo dyes, they are also important in the formation of peptide linkage in proteins and also in synthetic polymerspolymers

Carboxylic acid- FromWikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Carboxylic_acid

Abstract: Carboxylic acids are organic acids characterized by the presence of a **carboxyl group**, which has the formula -(C=O)-OH, usually written as **-COOH**. In general, the salts and anions of carboxylic acids are called **carboxylates**

The simplest series of carboxylic acids are the **alkanoic acids**, R-COOH, where R is a hydrogen or an alkyl group. Compounds may also have two or more carboxylic acid groups per molecule.

Rationale: Carboxylic acids are a group of compounds of great importance in fats and oils and also in ester formatiom in synthetic polymer chemistry. It is important that the student understands their chemistry. This article is a good introduction to the chemistry of carboxylic acids

Reading #3

Complete reference : Ester-From Wikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Ester

Abstract : This article deals with the chemistry of esters It deals with naming esters, physical properties, synthesis and reactions of esters. At the end there are also external links which discuss interesting aspects of esters including their flavours like that of ripe banana. This is an interesting article for the student to learn the importance of sters in life.

Rationale: This article will expose the student to interesting chemistry of esters and thus learn important reaction like the dieckmann condensation. The different search engines will expose the student to a lot of chemistry on esters, carboxylic acids and alcohols and their reactions

XII. Compulsory Resources

Resource #1

Complete reference :Refer to the File Korane (Organic I)

Abstract : the links and the books above details about the aliphatic hyrdocarbons
Rationale: Organic chemistry is the chemistry of compounds which contain carbon - which is a vast number of compounds. Carbon forms more compounds than any other element except hydrogen.

Resource #2

Complete reference :

Abstract : the links and the books above details about the aliphatic hyrdocarbons
Rationale: Organic chemistry is the chemistry of compounds which contain carbon -which is a vast number of compounds. Carbon forms more compounds than any other element except hydrogen.

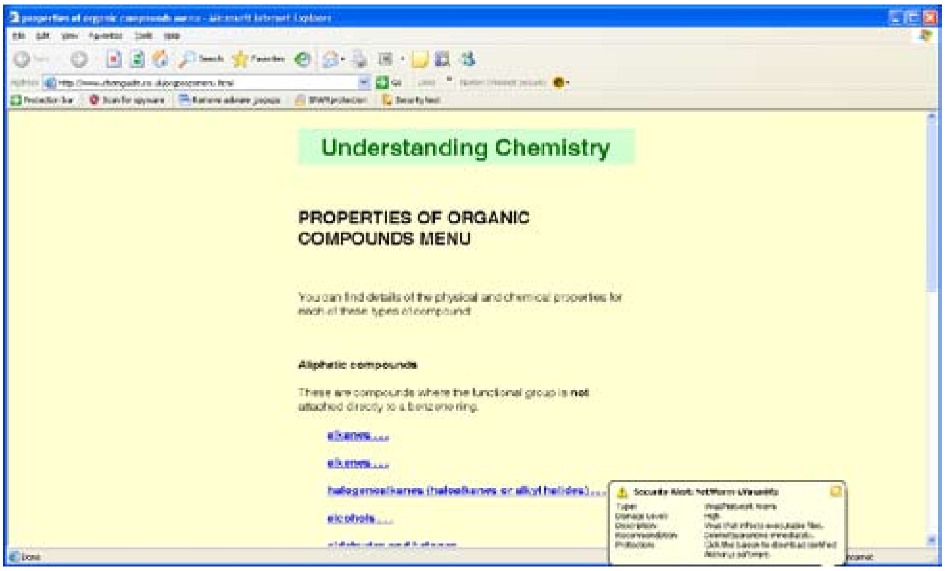
XIII. Useful Links

Useful Link #1

Title: Understanding chemistry: Properties of organic compounds menu

URL: ***http:www.chemguide.co.uk/orgpropsmenu.html***

Screen Capture



Understanding Chemistry

PROPERTIES OF ORGANIC COMPOUNDS MENU

You can find details of the physical and chemical properties for each of these types of compound.

Aliphatic compounds

These are compounds where the functional group is **not** attached directly to a benzene ring.

alkanes . . .

alkenes . . .

halogenoalkanes (haloalkanes or alkyl halides) . . .

alcohols . . .

Description : Properties of organic compounds menu deals with properties of alkanes, alkenes, haloalkanes (alkyl halides, alcohols, aldehydes and ketones, carboxylic acids, esters, acid anhydrides acyl halides in short It deals with aliphatic aromatic compounds under the different topics. Folloeup of the topics will expose the student to the chemistry of the different functional groups

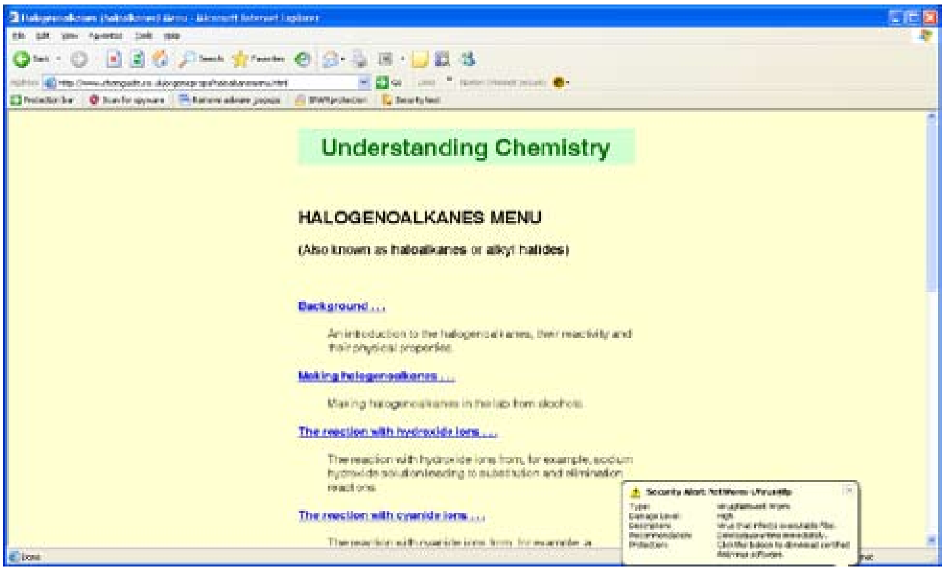
Rationale: this menu will give a hint to the student about the different topics to be covered.

Useful link # 2

Title: Understanding chemistry: halogenoalkanesmenu

URL: http://www.chemguide.co.uk/organicprops/haloalkanesmenu.html

Screen Capture



Understanding Chemistry

HALOGENOALKANES MENU

(Also known as haloalkanes or alkyl halides)

Background . . .

Making halogenoalkanes . . .

The reaction with hydroxide ions . . .

The reaction with cyanide ions . . .

Description: An introduction to the halogenoalkanes, their reactivity and their physical properties.

Making halogenoalkanes . . . Making halogenoalkanes in the lab from alcohols.

Reactions with hydroxide ions:
The reaction with hydroxide ions from, for example, sodium hydroxide solution leading to substitution and elimination reactions.

The reaction with cyanide ions . . .

The reaction with cyanide ions from, for example, a solution of potassium cyanide in alcohol.

The reaction with ammonia . . .

The reaction with ammonia to produce various kinds of amines.

Reactions involving silver nitrate solution . . .

Includes testing for halogenoalkanes, and the use of silver nitrate solution as a guide to the reactivity of the various halogenoalkanes.

Grignard reagents . . .

An introduction to Grignard reagents, including making them from halogenoalkanes and some of their simple reactions.

Uses of halogenoalkanes . . .

Including the problems associated with CFCs.

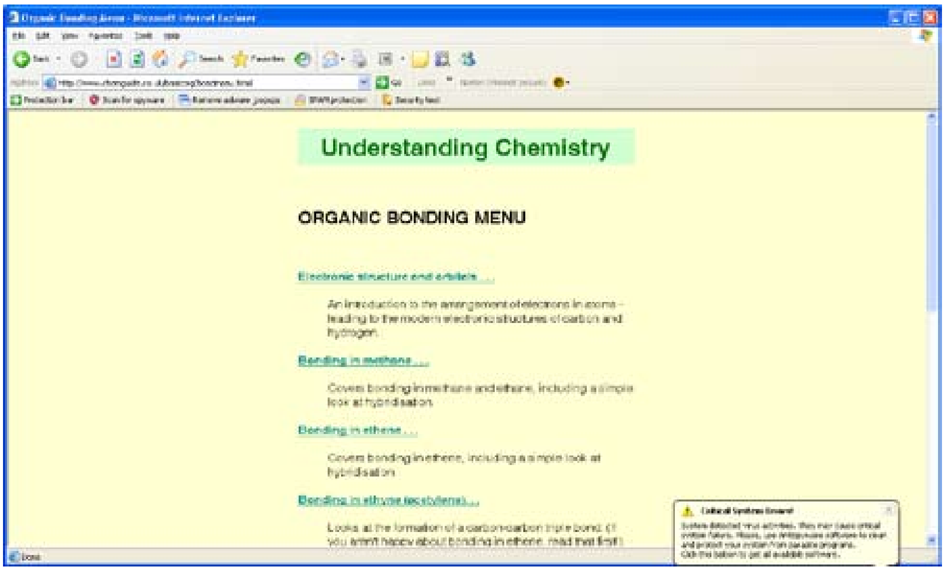
Rationale : This clearly outlines all that is needed to be covered under alkyl halides. Chemistry of alkyl halides is rich as shown by the type of reaction they undergo and the products obtained. It is important that one gets good understanding of this topic

Useful Links # 3

Title: Organic bonding menu

URL: http://www.chemguide.co.uk/basicorg/bondmenu.html

Screen Capture



Understanding Chemistry

ORGANIC BONDING MENU

Description: **Electronic structure and orbitals . . .**

An introduction to the arrangement of electrons in atoms - leading to the modern electronic structures of carbon and hydrogen.

Bonding in methane . . .

Covers bonding in methane and ethane, including a simple look at hybridisation.

Bonding in ethene . . .

Covers bonding in ethene, including a simple look at hybridisation.

Bonding in ethyne (acetylene). . .

Looks at the formation of a carbon-carbon triple bond. (If you aren't happy about bonding in ethene, read that first!)

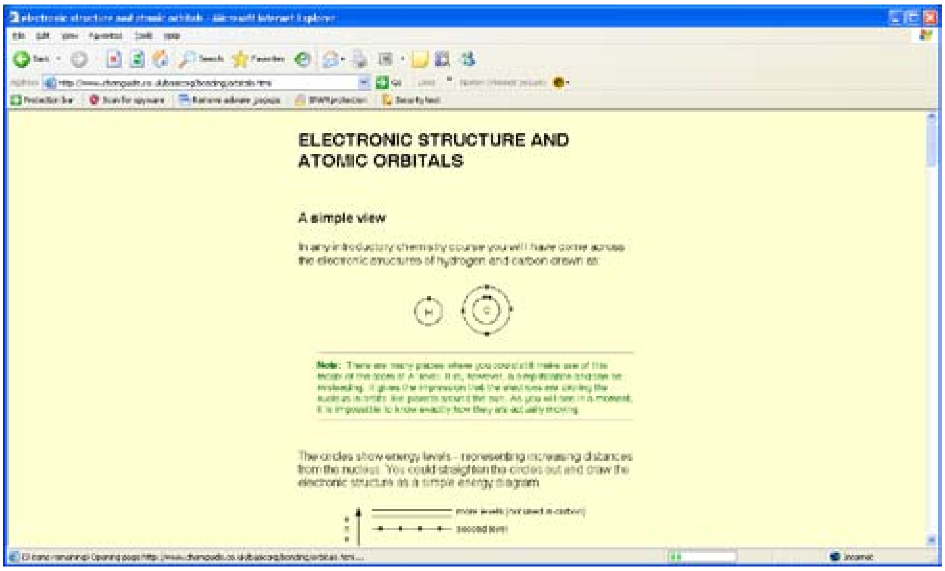
Rationale : Going through this article will expose the student to the concept of bonding in the different aliphatic aromatic compouds to understand well this aspect of chemistry

Useful link # 4

Title: Electronic structure and atomic orbitals

URL: *http://www.chemguide.co.uk/basicorg/bonding/orbitals.html*

Screen Capture

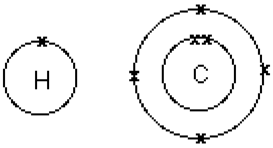


ELECTRONIC STRUCTURE AND ATOMIC ORBITALS

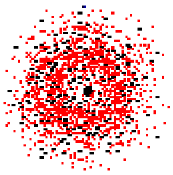
A simple view

Description: A simple view

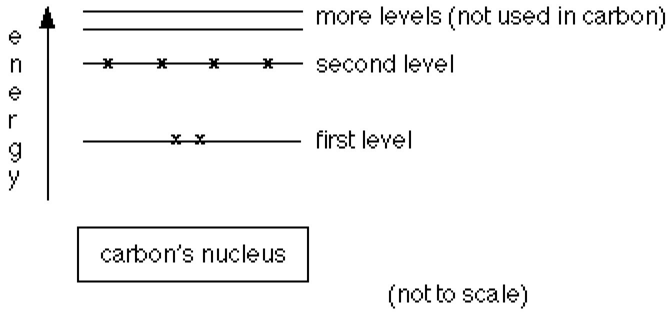
In any introductory chemistry course you will have come across the electronic structures of hydrogen and carbon drawn as:



The circles show energy levels - representing increasing distances from the nucleus. You could straighten the circles out and draw the electronic structure as a simple energy diagram.



a 1s orbital



Atomic orbitals

Orbits and orbitals sound similar, but they have quite different meanings. It is essential that you understand the difference between them.

The impossibility of drawing orbits for electrons

To plot a path for something you need to know exactly where the object is and be able to work out exactly where it's going to be an instant later. You can't do this for electrons.

The ***Heisenberg Uncertainty Principle*** (not required at A'level) says - loosely - that you can't know with certainty both where an electron is and where it's going next. That makes it impossible to plot an orbit for an electron around a nucleus. Is this a big problem? No. If something is impossible, you have to accept it and find a way around it.

Hydrogen's electron - the 1s orbital

Suppose you had a single hydrogen atom and at a particular instant plotted the position of the one electron. Soon afterwards, you do the same thing, and find that it is in a new position. You have no idea how it got from the first place to the second.

You keep on doing this over and over again, and gradually build up a sort of 3D map of the places that the electron is likely to be found.

In the hydrogen case, the electron can be found anywhere within a spherical space surrounding the nucleus. The diagram shows a *cross-section* through this spherical space.

95% of the time (or any other percentage you choose), the electron will be found within a fairly easily defined region of space quite close to the nucleus. Such a region of space is called an ***orbital.*** You can think of an orbital as being the region of space in which the electron lives.

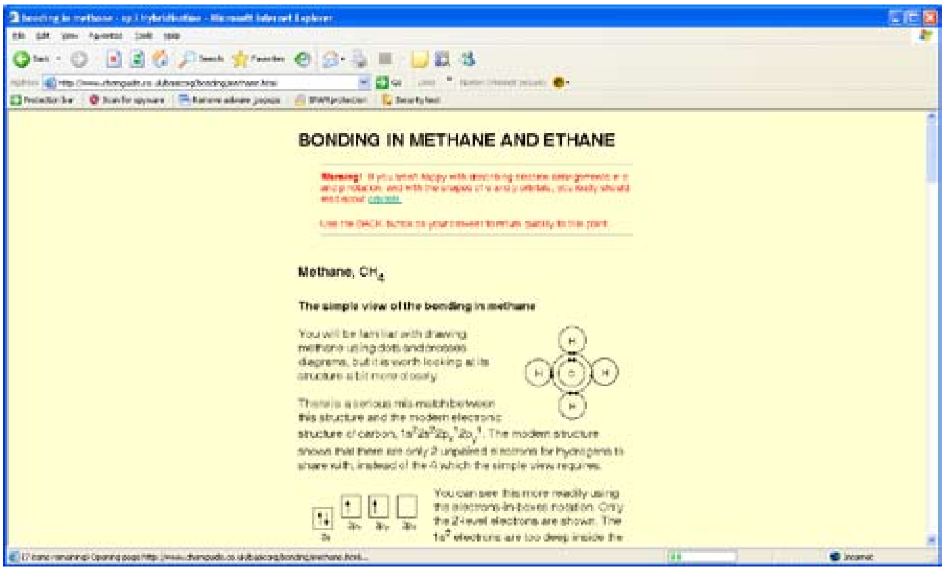
Rationale : Agood discussion on theory of bonding is given in a manner that can be understood at this level

Useful Link 5

Title: Bonding in methane and ethane-sp^3 hybridisation

http://www.chemguide.co.uk/basicorg/bonding/methane.html

Screen Capture



BONDING IN METHANE AND ETHANE

Methane, CH_4

The simple view of the bonding in methane

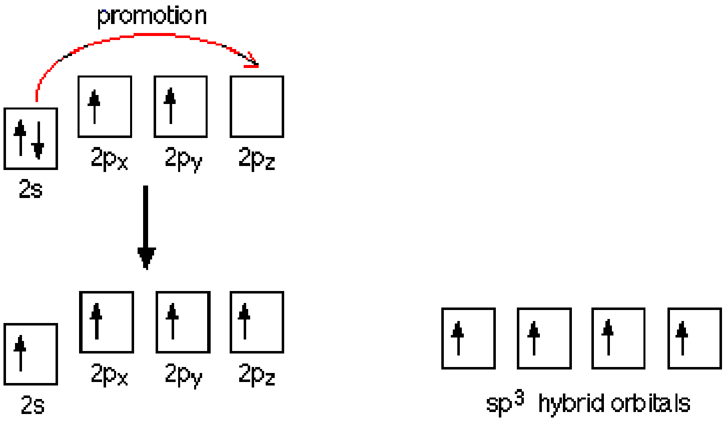
Description: Methane, CH_4

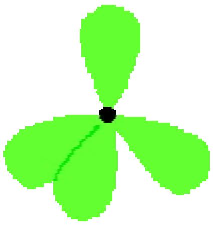
The simple view of the bonding in methane

You will be familiar with drawing methane using dots and crosses diagrams, but it is worth looking at its structure a bit more closely.

There is a serious mis-match between this structure and the modern electronic structure of carbon, $1s^22s^22p_x^{\,1}2p_y^{\,1}$. The modern structure shows that there are only 2 unpaired electrons for hydrogens to share with, instead of the 4 which the simple view requires.

You can see this more readily using the electrons-in-boxes notation. Only the 2-level electrons are shown. The $1s^2$ electrons are too deep inside the atom to be involved in bonding. The only electrons directly available for sharing are the 2p electrons. Why then isn't methane CH_2?





Promotion of an electron

When bonds are formed, energy is released and the system becomes more stable. If carbon forms 4 bonds rather than 2, twice as much energy is released and so the resulting molecule becomes even more stable.

There is only a small energy gap between the 2s and 2p orbitals, and so it pays the carbon to provide a small amount of energy to promote an electron from the 2s to the empty 2p to give 4 unpaired electrons. The extra energy released when the bonds form more than compensates for the initial input.

Now that we've got 4 unpaired electrons ready for bonding, another problem arises. In methane all the carbon-hydrogen bonds are identical, but our electrons are in two different kinds of orbitals. You aren't going to get four identical bonds unless you start from four identical orbitals.

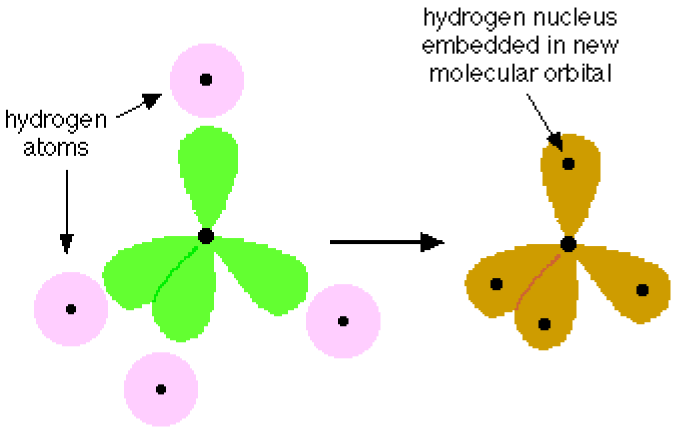
Hybridisation

The electrons rearrange themselves again in a process called hybridisation. This reorganizes the electrons into four identical hybrid orbitals called sp^3 hybrids (because they are made from one s orbital and three p orbitals). You should read "sp^3" as "s p three" - not as "s p cubed".

sp^3 hybrid orbitals look a bit like half a p orbital, and they arrange themselves in space so that they are as far apart as possible. You can picture the nucleus as being at the centre of a tetrahedron (a triangularly based pyramid) with the orbitals pointing to the corners. For clarity, the nucleus is drawn far larger than it really is.

What happens when the bonds are formed?

Remember that hydrogen's electron is in a 1s orbital - a spherically symmetric region of space surrounding the nucleus where there is some fixed chance (say 95%) of finding the electron. When a covalent bond is formed, the atomic orbitals (the orbitals in the individual atoms) merge to produce a new molecular orbital which contains the electron pair which creates the bond.



Four molecular orbitals are formed, looking rather like the original sp^3 hybrids, but with a hydrogen nucleus embedded in each lobe. Each orbital holds the 2 electrons that we've previously drawn as a dot and a cross.

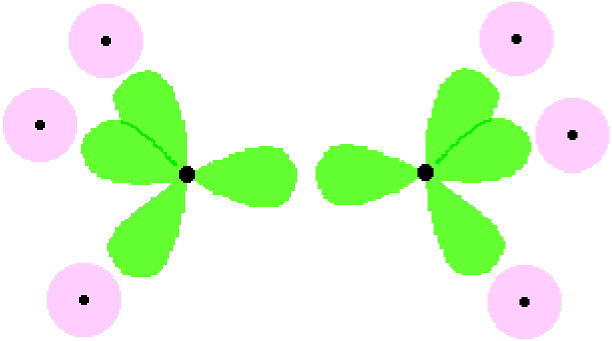
The principles involved - promotion of electrons if necessary, then hybridisation, followed by the formation of molecular orbitals - can be applied to any covalently-bound molecule.

Ethane, C_2H_6

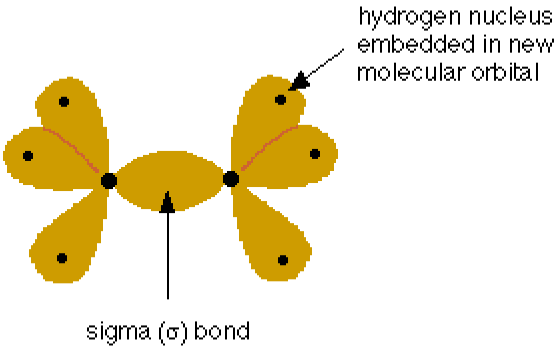
The formation of molecular orbitals in ethane

Ethane isn't particularly important in its own right, but is included because it is a simple example of how a carbon-carbon single bond is formed.

Each carbon atom in the ethane promotes an electron and then forms sp^3 hybrids exactly as we've described in methane. So just before bonding, the atoms look like this:



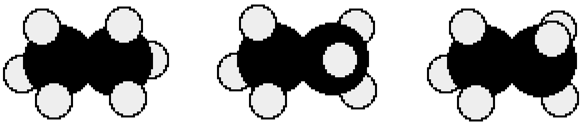
The hydrogens bond with the two carbons to produce molecular orbitals just as they did with methane. The two carbon atoms bond by merging their remaining sp^3 hybrid orbitals end-to-end to make a new molecular orbital. The bond formed by this end-to-end overlap is called a ***sigma bond.*** The bonds between the carbons and hydrogens are also sigma bonds.



In any sigma bond, the most likely place to find the pair of electrons is on a line between the two nuclei.

Free rotation about the carbon-carbon single bond

The two ends of this molecule can spin quite freely about the sigma bond so that there are, in a sense, an infinite number of possibilities for the shape of an ethane molecule. Some possible shapes are:



In each case, the left hand CH_3 group has been kept in a constant position so that you can see the effect of spinning the right hand one.

Other alkanes

All other alkanes will be bonded in the same way:

- The carbon atoms will each promote an electron and then hybridize to give sp^3 hybrid orbitals.
- The carbon atoms will join to each other by forming sigma bonds by the end-to-end overlap of their sp^3 hybrid orbitals.
- Hydrogen atoms will join on wherever they are needed by overlapping their $1s^1$ orbitals with sp^3 hybrid orbitals on the carbon atoms.

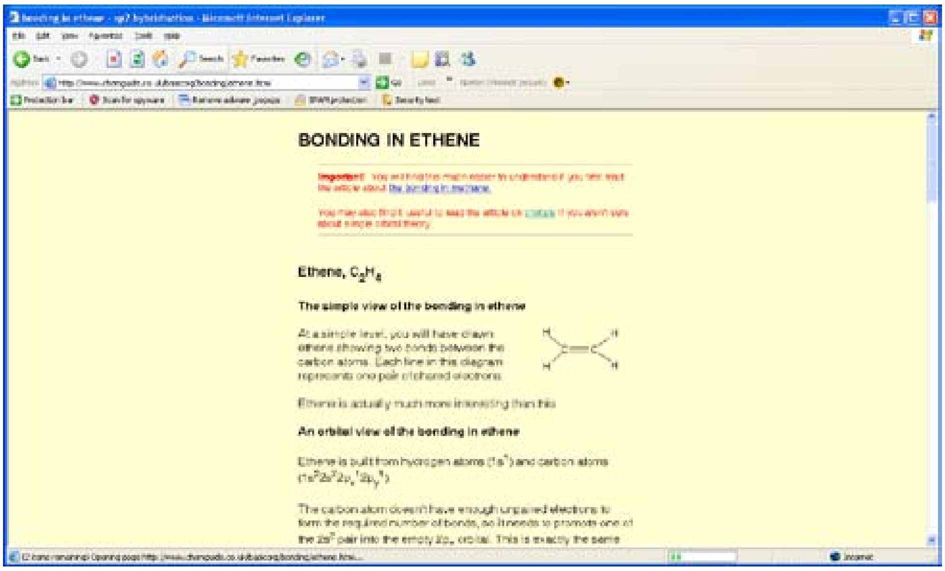
Rationale : The knowledge sp^3 hybridisation on bonding in methane and ethane is applicable for bonding in other alkanes. It introduces very well the concept of sp3 hybridisation

Useful Link 6

Title: Bonding in Ethene-sp^2 hybridisation

http://www.chemguide.co.uk/basicorg/bonding/ethene.html

Screen Capture



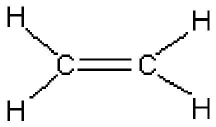
BONDING IN ETHENE

Ethene, C_2H_4

The simple view of the bonding in ethene

An orbital view of the bonding in ethene

Description: Ethene, C_2H_4



The simple view of the bonding in ethene

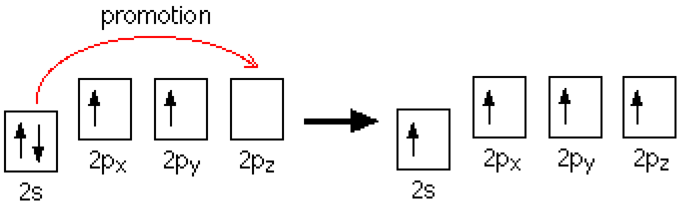
At a simple level, you will have drawn ethene showing two bonds between the carbon atoms. Each line in this diagram represents one pair of shared electrons.

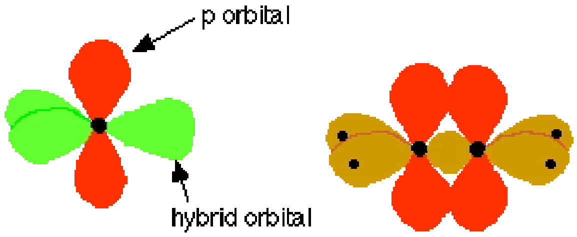
Ethene is actually much more interesting than this.

An orbital view of the bonding in ethene

Ethene is built from hydrogen atoms ($1s^1$) and carbon atoms ($1s^2 2s^2 2p_x^1 2p_y^1$).

The carbon atom doesn't have enough unpaired electrons to form the required number of bonds, so it needs to promote one of the $2s^2$ pair into the empty $2p_z$ orbital. This is exactly the same as happens whenever carbon forms bonds - whatever else it ends up joined to.

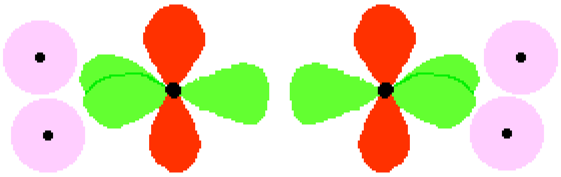




Now there's a difference, because each carbon is only joining to three other atoms rather than four - as in methane or ethane. When the carbon atoms hybridize their outer orbitals before forming bonds, this time they only hybridize *three* of the orbitals rather than all four. They use the 2s electron and two of the 2p electrons, but leave the other 2p electron unchanged.

The new orbitals formed are called ***sp^2 hybrids***, because they are made by an s orbital and two p orbitals reorganizing themselves. sp^2 orbitals look rather like sp^3 orbitals that you have already come across in the bonding in methane, except that they are shorter and fatter. The three sp^2 hybrid orbitals arrange themselves as far apart as possible - which is at 120° to each other in a plane. The remaining p orbital is at right angles to them.

The two carbon atoms and four hydrogen atoms would look like this before they joined together:



The various atomic orbitals which are pointing towards each other now merge to give molecular orbitals, each containing a bonding pair of electrons. These are ***sigma bonds*** - just like those formed by end-to-end overlap of atomic orbitals in, say, ethane.

The p orbitals on each carbon aren't pointing towards each other, and so we'll leave those for a moment. In the diagram, the black dots represent the nuclei of the atoms.

Notice that the p orbitals are so close that they are overlapping sideways.

This sideways overlap also creates a molecular orbital, but of a different kind. In this one the electrons aren't held on the line between the two nuclei, but above and below the plane of the molecule. A bond formed in this way is called a ***pi bond.***

For clarity, the sigma bonds are shown using lines - each line representing one pair of shared electrons. The various sorts of line show the directions the bonds point in. An ordinary line represents a bond in the plane of the screen (or the paper if you've printed it); a broken line is a bond going back away from you, and a wedge shows a bond coming out towards you.

Even if your syllabus doesn't expect you to know how a pi bond is formed, it will expect you to know that it exists. The pi bond dominates the chemistry of ethene. It is very vulnerable to attack - a very negative region of space above and below the plane of the molecule. It is also somewhat distant from the control of the nuclei and so is a weaker bond than the sigma bond joining the two carbons.

All double bonds (whatever atoms they might be joining) will consist of a sigma bond and a pi bond.

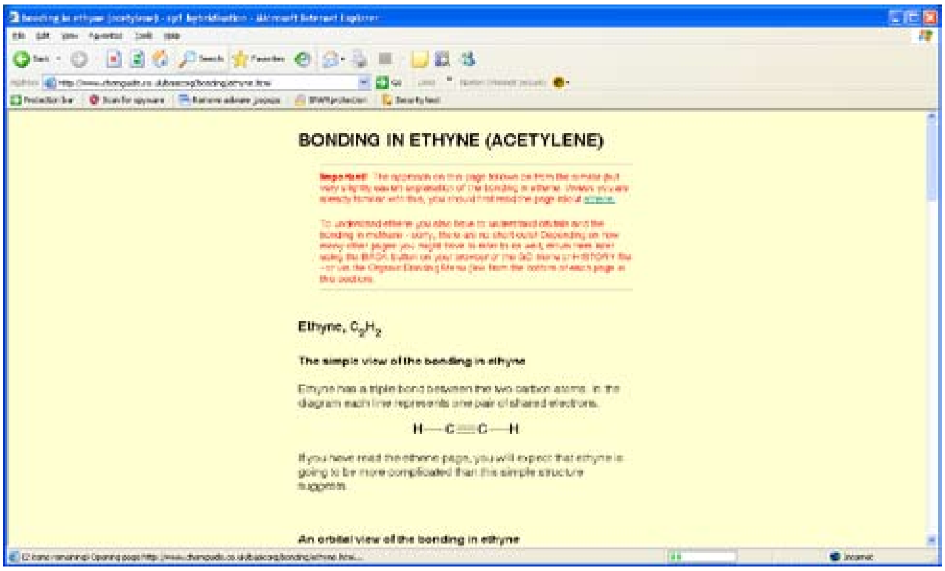
Rationale : A good introduction to the concept of sp2 hybridisation is given. This should be good knowledge to help understand bonding in other alkenes also.

Useful Link 7

Title: Bonding in Ethyne (Acetylene)-sp^1 hybridisation

http:/www./chemguide.co.uk/basicorg/bonding/ethyne.html

Screen Capture



BONDING IN ETHYNE (ACETYLENE)

Ethyne, C_2H_2

The simple view of the bonding in ethyne

H—C≡C—H

An orbital view of the bonding in ethyne

Description: Important! The approach on this page follows on from the similar (but very slightly easier) explanation of the bonding in ethene. Unless you are already familiar with this, you should first read the page about ethene.

To understand ethene you also have to understand orbitals and the bonding in methane - sorry, there are no short-cuts! Depending on how many other pages you might have to refer to as well, return here later using the BACK button on your browser or the GO menu or HISTORY file - or via the Organic Bonding Menu (link from the bottom of each page in this section).

Ethyne, C_2H_2

The simple view of the bonding in ethyne

Ethyne has a triple bond between the two carbon atoms. In the diagram each line represents one pair of shared electrons.

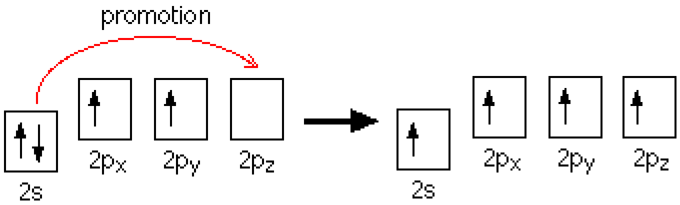
$$H—C\equiv C—H$$

If you have read the ethene page, you will expect that ethyne is going to be more complicated than this simple structure suggests.

An orbital view of the bonding in ethyne

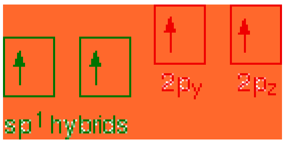
Ethyne is built from hydrogen atoms ($1s^1$) and carbon atoms ($1s^22s^22p_x^12p_y^1$).

The carbon atom doesn't have enough unpaired electrons to form four bonds (1 to the hydrogen and three to the other carbon), so it needs to promote one of the $2s^2$ pair into the empty $2p_z$ orbital. This is exactly the same as happens whenever carbon forms bonds - whatever else it ends up joined to.

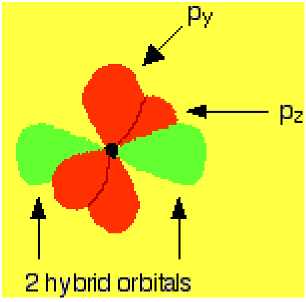


Each carbon is only joining to two other atoms rather than four (as in methane or ethane) or three (as in ethene) and so when the carbon atoms hybridize their outer orbitals before forming bonds, this time they only hybridize *two* of the orbitals.

They use the 2s electron and one of the 2p electrons, but leave the other 2p electrons unchanged. The new hybrid orbitals formed are called ***sp¹ hybrids*** (sometimes just sp hybrids), because they are made by an s orbital and a single p orbital reorganizing themselves.

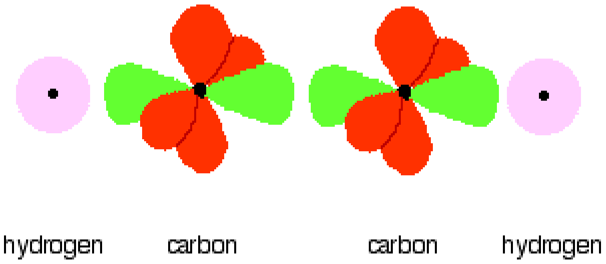


What these look like in the atom (using the same colour coding) is:



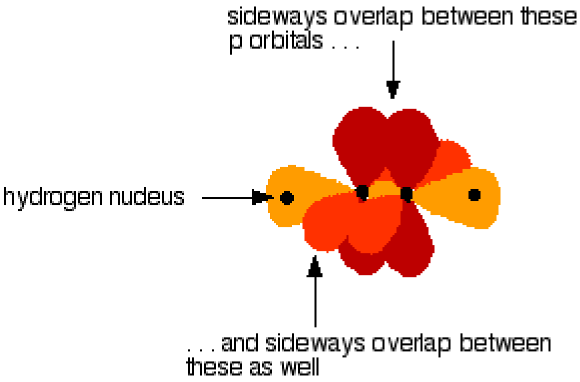
Notice that the two green lobes are two *different* hybrid orbitals - arranged as far apart from each other as possible. Don't confuse them with the shape of a p orbital.

The two carbon atoms and two hydrogen atoms would look like this before they joined together:

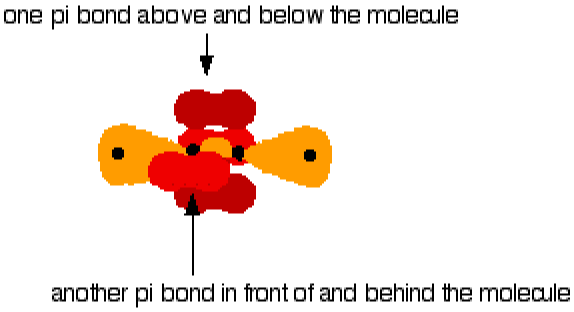


The various atomic orbitals which are pointing towards each other now merge to give molecular orbitals, each containing a bonding pair of electrons. These are ***sigma bonds*** - just like those formed by end-to-end overlap of atomic orbitals in, say, ethane. The sigma bonds are shown as orange in the next diagram.

The various p orbitals (now shown in slightly different reds to avoid confusion) are now close enough together that they overlap sideways.


sideways overlap between these p orbitals . . .
hydrogen nucleus
. . . and sideways overlap between these as well

Sideways overlap between the two sets of p orbitals produces two pi bonds - each similar to the pi bond found in, say, ethene. These pi bonds are at 90° to each other - one above and below the molecule, and the other in front of and behind the molecule. Notice the different shades of red for the two different pi bonds.


one pi bond above and below the molecule
another pi bond in front of and behind the molecule

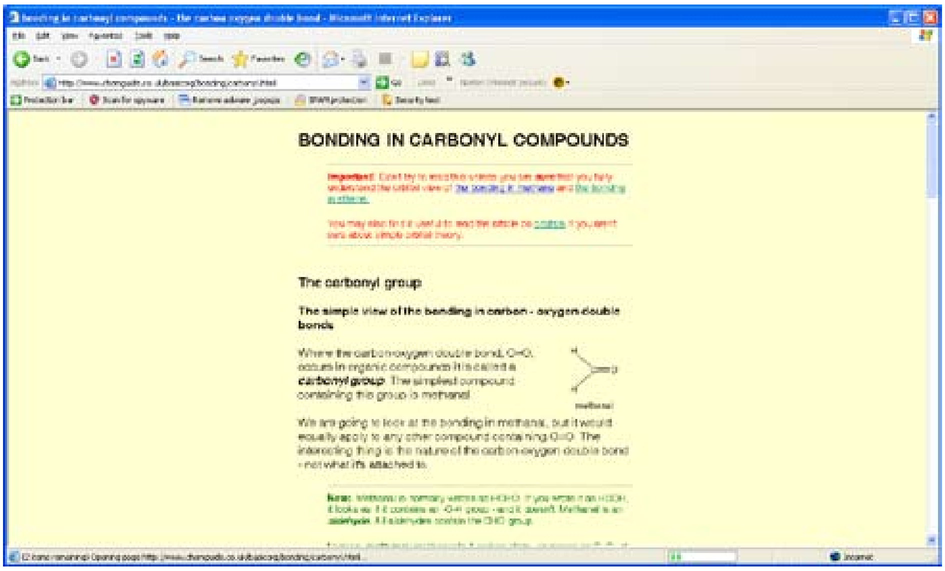
Rationale : Bonding in acetylene introduces you to the concept of sp hybridization typical of all triple bonded systems. This knowledge should be equally good for other alkyne systems

Useful link # 8

Title: Bonding in carbonyl compounds

URL: ***http://www.chemguide.co.uk/basicorg/bonding/carbonyl.html***

Screen Capture


BONDING IN CARBONYL COMPOUNDS

The carbonyl group

The simple view of the bonding in carbon - oxygen double bonds

Description: The carbonyl group

The simple view of the bonding in carbon - oxygen double bonds

Where the carbon-oxygen double bond, C=O, occurs in organic compounds it is called a ***carbonyl group***. The simplest compound containing this group is methanal.

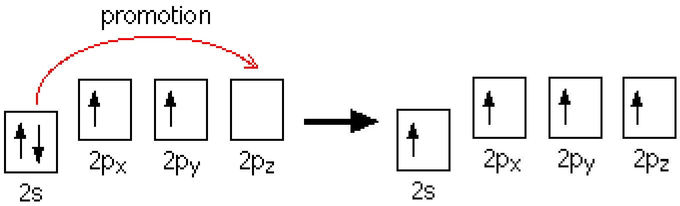
We are going to look at the bonding in methanal, but it would equally apply to any other compound containing C=O. The interesting thing is the nature of the carbon-oxygen double bond - not what it's attached to.

An orbital view of the bonding in carbon - oxygen double bonds

The carbon atom

Just as in ethene or benzene, the carbon atom is joined to three other atoms. The carbon's electrons rearrange themselves, and promotion and hybridization give sp^2 hybrid orbitals.

Promotion gives:



Hybridization of the 2s orbital and two of the 2p orbitals means that the carbon atom now looks like the diagram on the right.

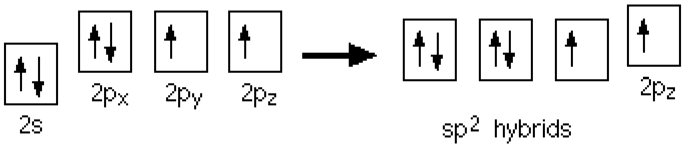
Three sp^2 hybrid orbitals are formed and these arrange themselves as far apart in space as they can - at 120° to each other. The remaining p orbital is at right angles to them.

This is exactly the same as in ethene or in benzene.

The oxygen atom

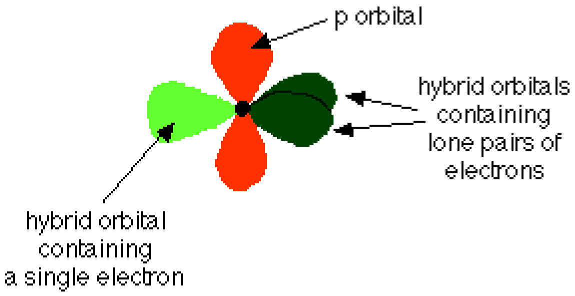
Oxygen's electronic structure is $1s^22s^22p_x^{\ 2}2p_y^{\ 1}2p_z^{\ 1}$.

The 1s electrons are too deep inside the atom to be concerned with the bonding and so we'll ignore them from now on. Hybridization occurs in the oxygen as well. It is easier to see this using "electrons-in-boxes".

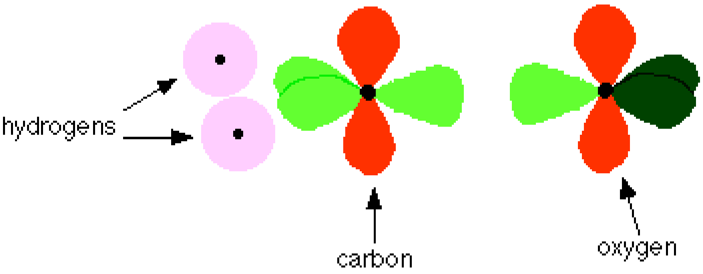


This time two of the sp^2 hybrid orbitals contain lone pairs of electrons.

Help! A “lone pair” of electrons is a pair of electrons at the bonding level which isn’t being used to bond on to another atom.

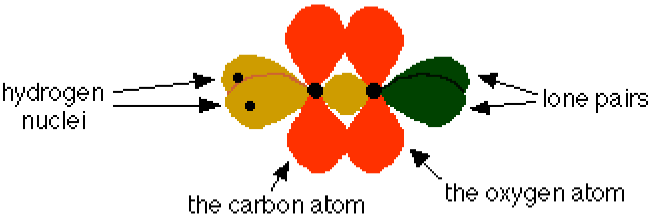

p orbital
hybrid orbitals containing lone pairs of electrons
hybrid orbital containing a single electron

The carbon atom and oxygen atom then bond in much the same way as the two carbons do in ethene. In the next diagram, we are assuming that the carbon will also bond to two hydrogens to make methanal - but it could equally well bond to anything else.



End-to-end overlap between the atomic orbitals that are pointing towards each other produce sigma bonds.

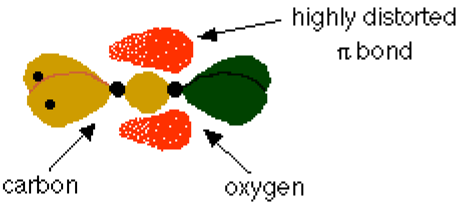
Notice that the p orbitals are overlapping sideways.



This sideways overlap produces a pi bond. So just like C=C, C=O is made up of a sigma bond and a pi bond.

Does that mean that the bonding is exactly the same as in ethene? No! The distribution of electrons in the pi bond is heavily distorted towards the oxygen end of the bond, because oxygen is much more electronegative than carbon.

Help! You can read about the origins of electronegativity and its effects in organic compounds in a separate article.



This distortion in the pi bond causes major differences in the reactions of compounds containing carbon-oxygen double bonds like methanal compared with compounds containing carbon-carbon double bonds like ethene.

Note: You can read about addition reactions or addition-elimination reactions of carbonyl compounds elswhere on this site.

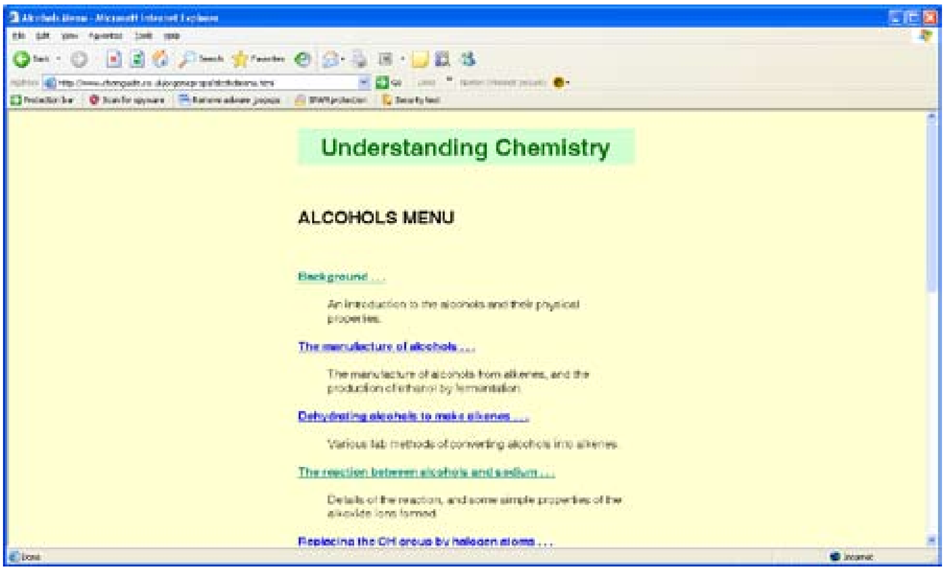
Rationale : The concept of bonding in carbony compounds is important to understand the chemistry of all carbonyl systems. The polar nature of the carbon-oxygen bond is pivotal to the reactions of carbonyl compounds. It is therefore important that this is well grasped.

Useful Link #9

Title: Understanding chemistry: Alcohols menu

URL: *http://www.chemguide.co.uk/organicprops/alcoholmenu.html*

Screen Capture



Understanding Chemistry

ALCOHOLS MENU

Background . . .

An introduction to the alcohols and their physical properties.

The manufacture of alcohols . . .

The manufacture of alcohols from alkenes, and the production of ethanol by fermentation.

Dehydrating alcohols to make alkenes . . .

Various lab methods of converting alcohols into alkenes.

The reaction between alcohols and sodium . . .

Details of the reaction, and some simple properties of the alkoxide ions formed.

Replacing the OH group by halogen atoms . . .

Description: Background . . .

An introduction to the alcohols and their physical properties.

The manufacture of alcohols . . .

The manufacture of alcohols from alkenes, and the production of ethanol by fermentation.

Dehydrating alcohols to make alkenes . . .

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The reaction between alcohols and sodium . . .

Details of the reaction and some simple properties of the alkoxide ions formed.

Replacing the OH group by halogen atoms . . .

The reactions between alcohols and phosphorus halides (such as phosphorus(V) chloride) or sulphur dichloride oxide (thionyl chloride), and mixtures such as sodium bromide and concentrated sulphuric acid. Includes testing for the OH group using PCl_5.

The oxidation of alcohols . . .

The oxidation of alcohols using acidified potassium dichromate(VI) solution, and its use in making aldehydes, ketones and carboxylic acids. Using the reaction as a test for primary, secondary and tertiary alcohols.

Making esters from alcohols . . .

Mainly the reaction between alcohols and carboxylic acids to produce esters, together at a brief look at making esters from the reactions between alcohols and acyl chlorides or acid anhydrides.

The triiodomethane (iodoform) reaction . . .

The use of this reaction to detect the presence of the $CH_3CH(OH)$ group in alcohols.

Uses of alcohols . . .

Concentrates on ethanol and methanol, but with some mention of propan-2-ol.

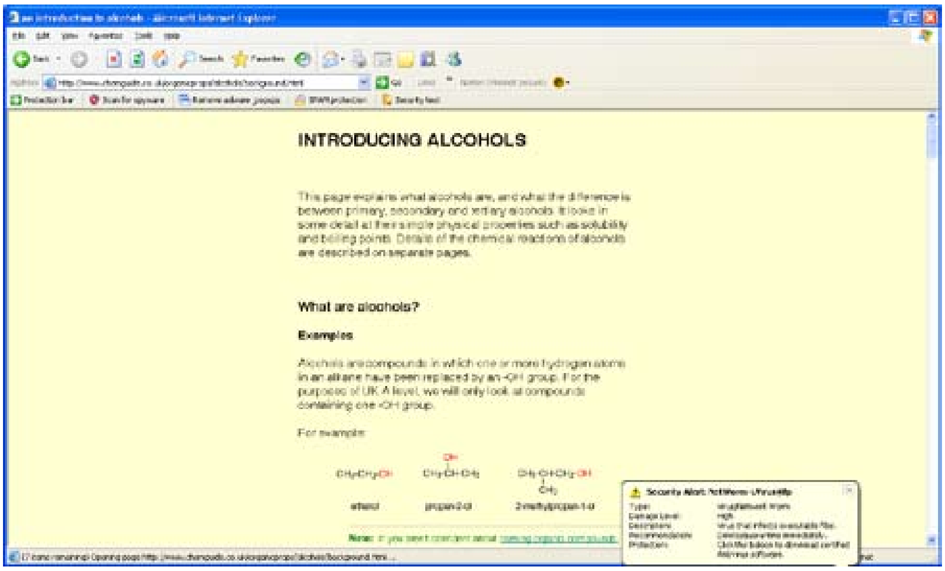
Rationale : The chemistry of alcohols is versatile as seen from its reactions. These reactions will be discussed in the links that follow. The nomenclature, classification physical properties are given in the immediate following link: “Introducing alcohols”

Useful Link #10

Title: Introducing alcohols

URL: ***http://www.chemguide.co.uk/organicprops/alcohols/background.html***

Screen Capture



Description: This page explains what alcohols are, and what the difference is between primary, secondary and tertiary alcohols. It looks in some detail at their simple physical properties such as solubility and boiling points. Details of the chemical reactions of alcohols are described on separate pages.

What are alcohols?

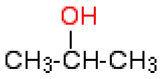
Examples

Alcohols are compounds in which one or more hydrogen atoms in an alkane have been replaced by an -OH group. For the purposes of UK A level, we will only look at compounds containing one -OH group.

For example:

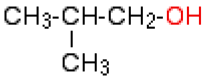
$CH_3\text{-}CH_2\text{-}OH$

ethanol



$CH_3\text{-}\overset{\overset{\displaystyle OH}{|}}{C}H\text{-}CH_3$

propan-2-ol



$CH_3\text{-}\underset{\underset{\displaystyle CH_3}{|}}{C}H\text{-}CH_2\text{-}OH$

2-methylpropan-1-ol

Note: If you aren't confident about naming organic compounds, then you really ought to follow this link before you go on.

Use the BACK button on your browser to return to this page.

The different kinds of alcohols

Alcohols fall into different classes depending on how the -OH group is positioned on the chain of carbon atoms. There are some chemical differences between the various types.

Primary alcohols

In a primary (1°) alcohol, the carbon which carries the -OH group is only attached to one alkyl group.

Note: An alkyl group is a group such as methyl, CH_3, or ethyl, CH_3CH_2. These are groups containing chains of carbon atoms which may be branched. Alkyl groups are given the general symbol **R.**

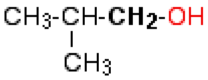
Some examples of primary alcohols include:

$CH_3\text{-}\mathbf{CH_2}\text{-}OH$

ethanol

$CH_3\text{-}CH_2\text{-}\mathbf{CH_2}\text{-}OH$

propan-1-ol



$CH_3\text{-}\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{-}\mathbf{CH_2}\text{-}OH$

2-methylpropan-1-ol

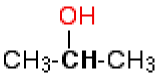
Notice that it doesn't matter how complicated the attached alkyl group is. In each case there is only ***one linkage*** to an alkyl group from the CH_2 group holding the -OH group.

There is an exception to this. Methanol, CH_3OH, is counted as a primary alcohol even though there are ***no*** alkyl groups attached to the carbon with the -OH group on it.

Secondary alcohols

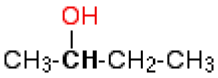
In a secondary (2°) alcohol, the carbon with the -OH group attached is joined directly to ***two*** alkyl groups, which may be the same or different.

Examples:



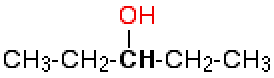
$CH_3\text{-}\overset{\displaystyle OH}{\overset{|}{\mathbf{CH}}}\text{-}CH_3$

propan-2-ol



$CH_3\text{-}\overset{\displaystyle OH}{\overset{|}{\mathbf{CH}}}\text{-}CH_2\text{-}CH_3$

butan-2-ol



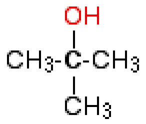
$CH_3\text{-}CH_2\text{-}\overset{\displaystyle OH}{\overset{|}{\mathbf{CH}}}\text{-}CH_2\text{-}CH_3$

pentan-3-ol

Tertiary alcohols

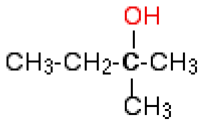
In a tertiary (3°) alcohol, the carbon atom holding the -OH group is attached directly to ***three*** alkyl groups, which may be any combination of same or different.

Examples:



$$CH_3\text{-}\overset{OH}{\underset{CH_3}{C}}\text{-}CH_3$$

2-methylpropan-2-ol



$$CH_3\text{-}CH_2\text{-}\overset{OH}{\underset{CH_3}{C}}\text{-}CH_3$$

2-methylbutan-2-ol

Physical properties of alcohols

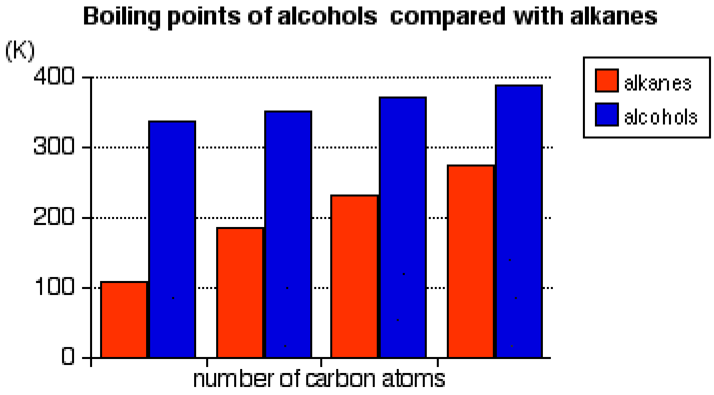
Boiling Points

The chart shows the boiling points of some simple primary alcohols with up to 4 carbon atoms.

They are:

CH_3OH	CH_3CH_2OH	$CH_3CH_2CH_2OH$	$CH_3CH_2CH_2CH_2OH$
methanol	ethanol	propan-1-ol	butan-1-ol

They are compared with the equivalent alkane (methane to butane) with the same number of carbon atoms.



Boiling points of alcohols compared with alkanes

Notice that:

- The boiling point of an alcohol is always much higher than that of the alkane with the same number of carbon atoms.
- The boiling points of the alcohols increase as the number of carbon atoms increases.

The patterns in boiling point reflect the patterns in intermolecular attractions.

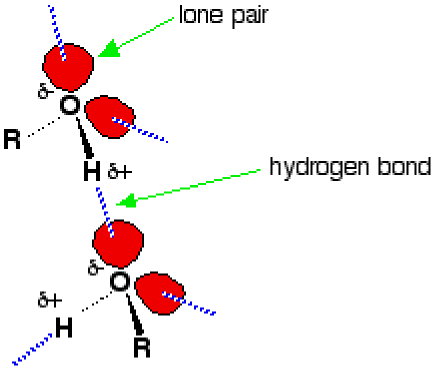
Note: If you aren't happy about intermolecular forces (including van der Waals dispersion forces and hydrogen bonds) then you really ought to follow this link before you go on. The next bit won't make much sense to you if you aren't familiar with the various sorts of intermolecular forces.

Use the BACK button on your browser to return to this page.

Hydrogen bonding

Hydrogen bonding occurs between molecules where you have a hydrogen atom attached to one of the very electronegative elements - fluorine, oxygen or nitrogen.

In the case of alcohols, there are hydrogen bonds set up between the slightly positive hydrogen atoms and lone pairs on oxygens in other molecules.



The hydrogen atoms are slightly positive because the bonding electrons are pulled away from them towards the very electronegative oxygen atoms.

Note: If you want to be fussy, the diagram is slightly misleading in that it suggests that all of the lone pairs on the oxygen atoms are forming hydrogen bonds. In an alcohol that can't happen. Taking the alcohol as a whole, there are only half as many slightly positive hydrogen atoms as there are lone pairs. At any one time, half of the lone pairs in the total liquid alcohol won't have hydrogen bonds from them because there aren't enough slightly positive hydrogens to go around.

In the diagram, to show the 3-dimensional arrangement, the wedge-shaped lines show bonds coming out of the screen or paper towards you. The dotted bonds (other than the hydrogen bonds) show bonds going back into the screen or paper away from you.

In alkanes, the only intermolecular forces are van der Waals dispersion forces. Hydrogen bonds are much stronger than these and therefore it takes more energy to separate alcohol molecules than it does to separate alkane molecules.

That's the main reason that the boiling points are higher.

The effect of van der Waals forces . . .

. . . on the boiling points of the alcohols:

Hydrogen bonding isn't the only intermolecular force in alcohols. There are also van der Waals dispersion forces and dipole-dipole interactions.

The hydrogen bonding and the dipole-dipole interactions will be much the same for all the alcohols, but the dispersion forces will increase as the alcohols get bigger.

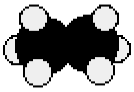
These attractions get stronger as the molecules get longer and have more electrons. That increases the sizes of the temporary dipoles that are set up.

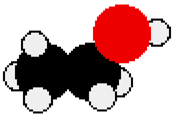
This is why the boiling points increase as the number of carbon atoms in the chains increases. It takes more energy to overcome the dispersion forces, and so the boiling points rise.

. . . on the comparison between alkanes and alcohols:

Even if there wasn't any hydrogen bonding or dipole-dipole interactions, the boiling point of the alcohol would be higher than the corresponding alkane with the same number of carbon atoms.

Compare ethane and ethanol:





Ethanol is a longer molecule, and the oxygen brings with it an extra 8 electrons. Both of these will increase the size of the van der Waals dispersion forces and so the boiling point.

If you were doing a really fair comparison to show the effect of the hydrogen bonding on boiling point it would be better to compare ethanol with propane rather than ethane. The length would then be much the same, and the number of electrons is exactly the same.

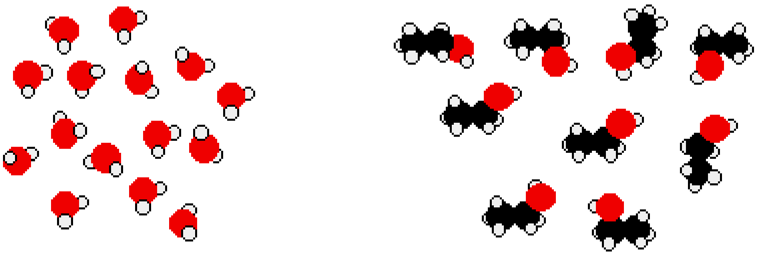
Solubility of alcohols in water

The small alcohols are completely soluble in water. Whatever proportions you mix them in, you will get a single solution.

However, solubility falls as the length of the hydrocarbon chain in the alcohol increases. Once you get to four carbons and beyond, the fall in solubility is noticeable, and you may well end up with two layers in your test tube.

The solubility of the small alcohols in water

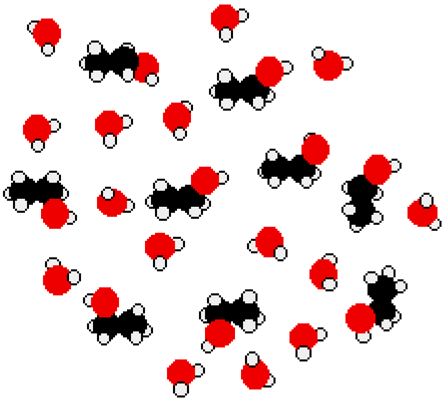
Consider ethanol as a typical small alcohol. In both pure water and pure ethanol the main intermolecular attractions are hydrogen bonds.



Both of these are held together mainly by hydrogen bonding.

In order to mix the two, you would have to break the hydrogen bonds between the water molecules and the hydrogen bonds between the ethanol molecules. It needs energy to do both of these things.

However, when the molecules are mixed, new hydrogen bonds are made between water molecules and ethanol molecules.



New hydrogen bonds are set up between ethanol and water molecules.

The energy released when these new hydrogen bonds are made more or less compensates for that needed to break the original ones.

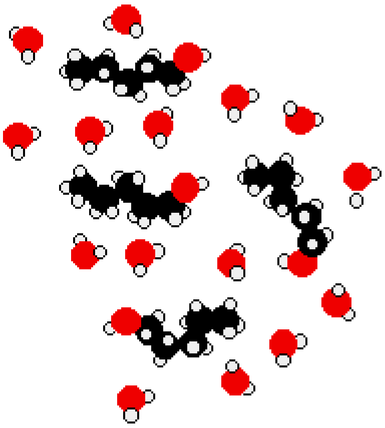
In addition, there is an increase in the disorder of the system - an increase in entropy. That is another factor in deciding whether things happen or not.

Note: If you haven't come across entropy before, don't worry about it. I mention it because the energy released when the new bonds are made isn't quite enough to compensate for breaking the old ones, meaning that the mixing process is endothermic. If it weren't for the increase in entropy, the solution wouldn't be formed.

To really understand this, you need to have studied entropy and free energy. If you should know about this, but aren't happy about the calculations involved, you might like to have a look at chapter 11 of my chemistry calculations book.

The lower solubility of bigger alcohols

Imagine what happens when you have got, say, 5 carbon atoms in each alcohol molecule.



The hydrocarbon chains are forcing their way between water molecules and so breaking hydrogen bonds between those water molecules.

The -OH end of the alcohol molecules can form new hydrogen bonds with water molecules, but the hydrocarbon «tail» doesn't form hydrogen bonds

That means that quite a lot of the original hydrogen bonds being broken aren't replaced by new ones.

All you get in place of those original hydrogen bonds are van der Waals dispersion forces between the water and the hydrocarbon «tails». These attractions are much weaker. That means that you don't get enough energy back to compensate for the hydrogen bonds being broken. Even allowing for the increase in disorder, the process becomes less feasible.

As the length of the alcohol increases, this situation just gets worse, and so the solubility falls.

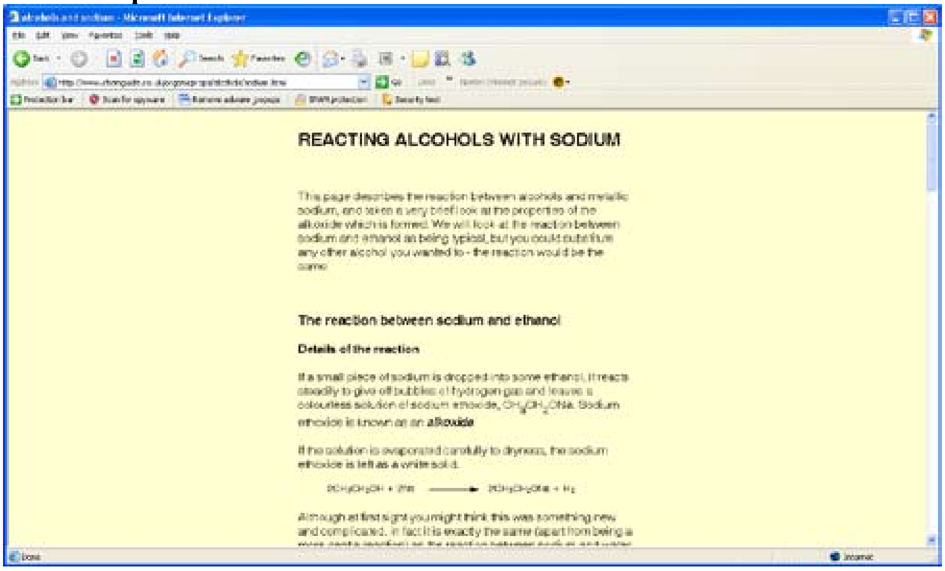
Rationale : A very good discussion of properties of alcohols is given. Clear illustrations are given to make you the student understands. Follow all the links given and you will like the article.

Useful Link # 11

Title : Reacting alcohols with sodium

URL: ***http://www.chemguide.co.uk/organicprops/alcohols/sodium.html***

Screen Capture



REACTING ALCOHOLS WITH SODIUM

This page describes the reaction between alcohols and metallic sodium, and takes a very brief look at the properties of the alkoxide which is formed. We will look at the reaction between sodium and ethanol as being typical, but you could substitute any other alcohol you wanted to - the reaction would be the same.

The reaction between sodium and ethanol

Details of the reaction

If a small piece of sodium is dropped into some ethanol, it reacts steadily to give off bubbles of hydrogen gas and leaves a colourless solution of sodium ethoxide, CH_3CH_2ONa. Sodium ethoxide is known as an **alkoxide**.

If the solution is evaporated carefully to dryness, the sodium ethoxide is left as a white solid.

$$2CH_3CH_2OH + 2Na \longrightarrow 2CH_3CH_2ONa + H_2$$

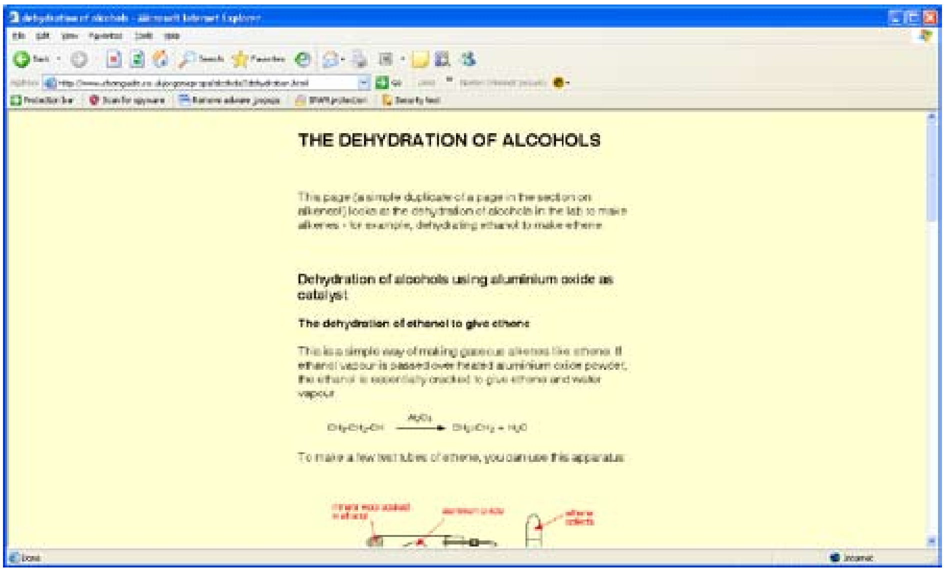
Although at first sight you might think this was something new and complicated, in fact it is exactly the same (apart from being a

Useful Link 12

Title : The dehydration of alcohols

URL: ***http://www.chemguide.co.uk/organicprops/alcohols//dehydration.html***

Screen Capture



THE DEHYDRATION OF ALCOHOLS

This page (a simple duplicate of a page in the section on alkenes!) looks at the dehydration of alcohols in the lab to make alkenes - for example, dehydrating ethanol to make ethene.

Dehydration of alcohols using aluminium oxide as catalyst

The dehydration of ethanol to give ethene

This is a simple way of making gaseous alkenes like ethene. If ethanol vapour is passed over heated aluminium oxide powder, the ethanol is essentially cracked to give ethene and water vapour.

$$CH_3CH_2OH \xrightarrow{Al_2O_3} CH_2{=}CH_2 + H_2O$$

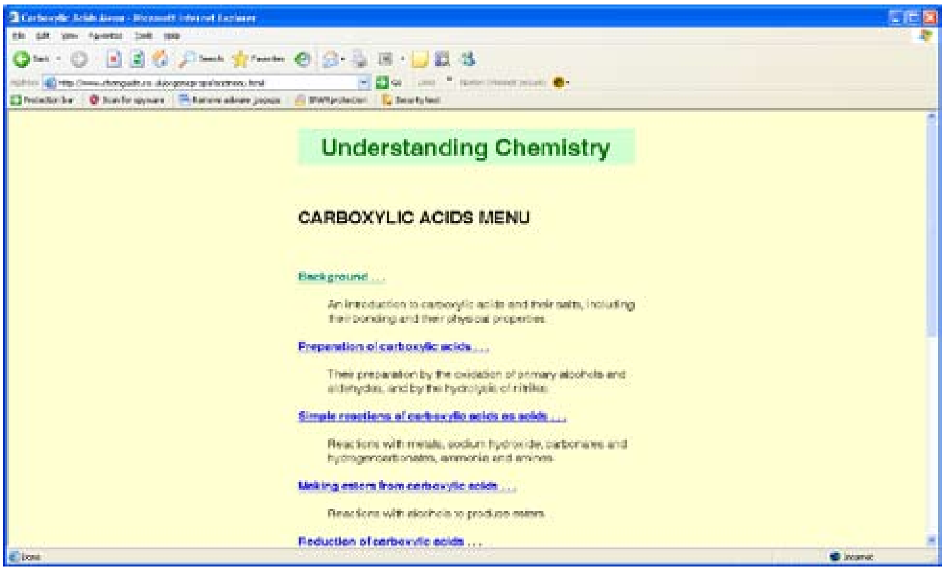
To make a few test tubes of ethene, you can use this apparatus:

Useful Link 13

Title : Understanding chemistry: Carboxylic acids menu

URL: ***http://chemguide.co.ukorganicprops/acidmenu.html***

Screen Capture



Understanding Chemistry

CARBOXYLIC ACIDS MENU

Background . . .

An introduction to carboxylic acids and their salts, including their bonding and their physical properties.

Preparation of carboxylic acids . . .

Their preparation by the oxidation of primary alcohols and aldehydes, and by the hydrolysis of nitriles.

Simple reactions of carboxylic acids as acids . . .

Reactions with metals, sodium hydroxide, carbonates and hydrogencarbonates, ammonia and amines.

Making esters from carboxylic acids . . .

Reactions with alcohols to produce esters.

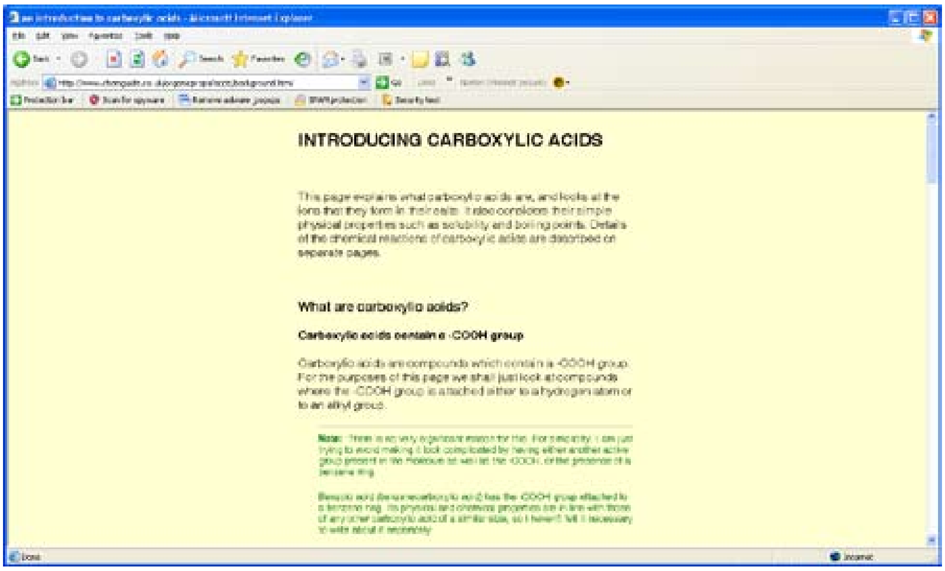
Reduction of carboxylic acids . . .

Useful Link 14

Title : Introducing carboxylic acids

URL: *http://www.chemguide.co.uk/organicprops/acids/background.html*

Screen Capture



INTRODUCING CARBOXYLIC ACIDS

This page explains what carboxylic acids are, and looks at the ions that they form in their salts. It also considers their simple physical properties such as solubility and boiling points. Details of the chemical reactions of carboxylic acids are described on separate pages.

What are carboxylic acids?

Carboxylic acids contain a -COOH group

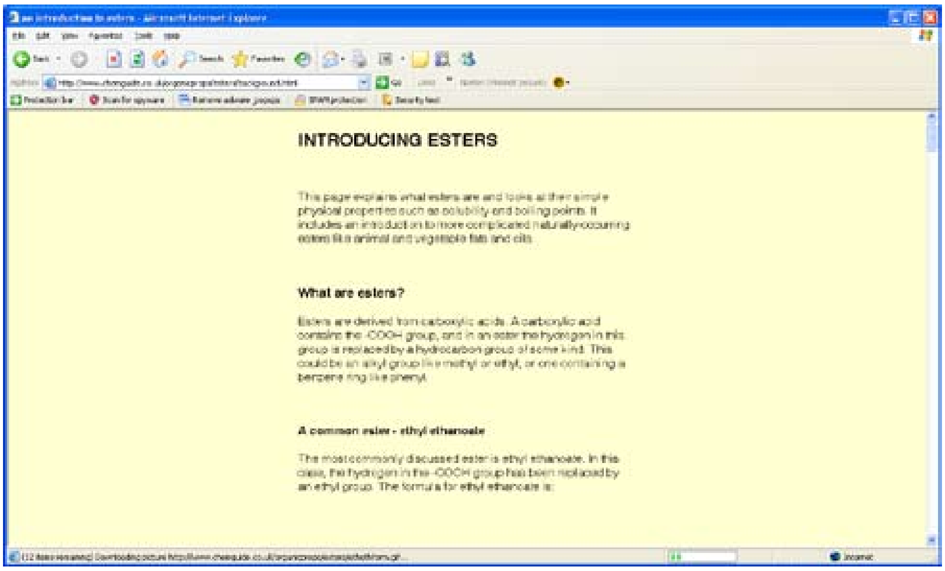
Carboxylic acids are compounds which contain a -COOH group. For the purposes of this page we shall just look at compounds where the -COOH group is attached either to a hydrogen atom or to an alkyl group.

Useful Link 15

Title :Introducing esters

URL: *http://www.chemguide.co.uk/organicprops/esters/background.html*

Screen Capture



INTRODUCING ESTERS

This page explains what esters are and looks at their simple physical properties such as solubility and boiling points. It includes an introduction to more complicated naturally-occurring esters like animal and vegetable fats and oils.

What are esters?

Esters are derived from carboxylic acids. A carboxylic acid contains the -COOH group, and in an ester the hydrogen in this group is replaced by a hydrocarbon group of some kind. This could be an alkyl group like methyl or ethyl, or one containing a benzene ring like phenyl.

A common ester - ethyl ethanoate

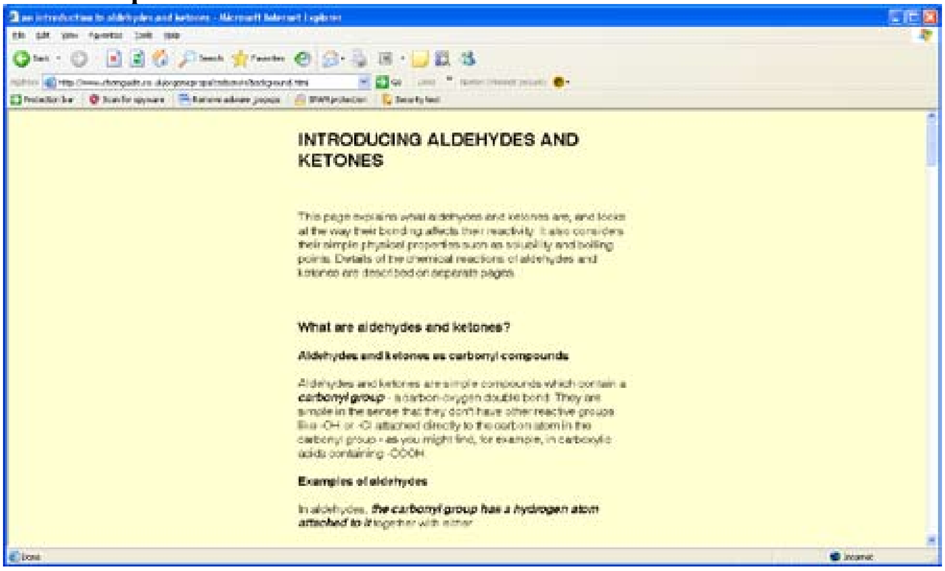
The most commonly discussed ester is ethyl ethanoate. In this case, the hydrogen in the -COOH group has been replaced by an ethyl group. The formula for ethyl ethanoate is:

Useful Link #16

Title : Introducing aldehydes and ketones

URL:*http://www.chemguide.co.uk/organicprops/carbonyls/background.html*

Screen Capture



INTRODUCING ALDEHYDES AND KETONES

This page explains what aldehydes and ketones are, and looks at the way their bonding affects their reactivity. It also considers their simple physical properties such as solubility and boiling points. Details of the chemical reactions of aldehydes and ketones are described on separate pages.

What are aldehydes and ketones?

Aldehydes and ketones as carbonyl compounds

Aldehydes and ketones are simple compounds which contain a ***carbonyl group*** - a carbon-oxygen double bond. They are simple in the sense that they don't have other reactive groups like -OH or -Cl attached directly to the carbon atom in the carbonyl group - as you might find, for example, in carboxylic acids containing -COOH.

Examples of aldehydes

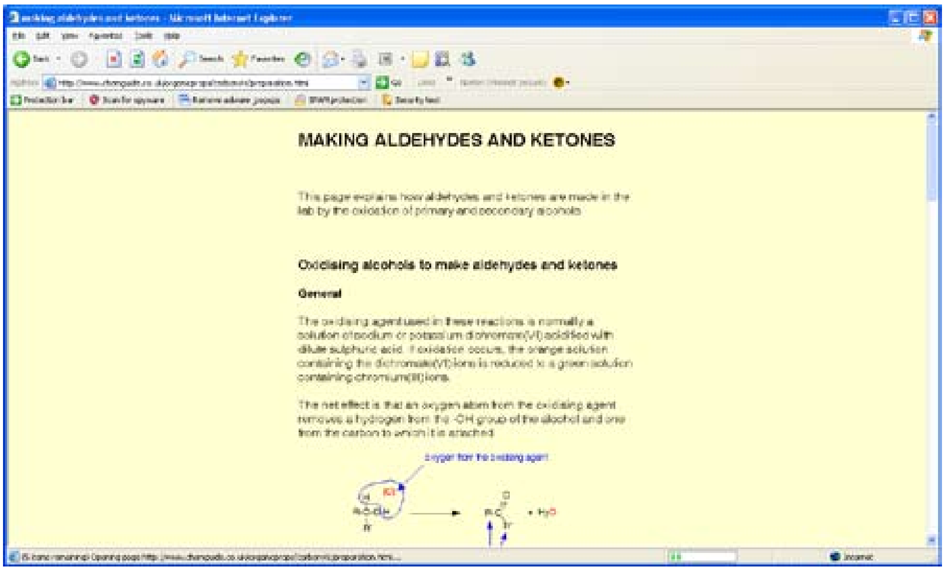
In aldehydes, ***the carbonyl group has a hydrogen atom attached to it*** together with either

Useful Link 17

Title : Making aldehydes and ketones

URL: *http://www.chemguide.co.uk/organicprops/carbonyls/preparation.html*

Screen Capture



MAKING ALDEHYDES AND KETONES

This page explains how aldehydes and ketones are made in the lab by the oxidation of primary and secondary alcohols.

Oxidising alcohols to make aldehydes and ketones

General

The oxidising agent used in these reactions is normally a solution of sodium or potassium dichromate(VI) acidified with dilute sulphuric acid. If oxidation occurs, the orange solution containing the dichromate(VI) ions is reduced to a green solution containing chromium(III) ions.

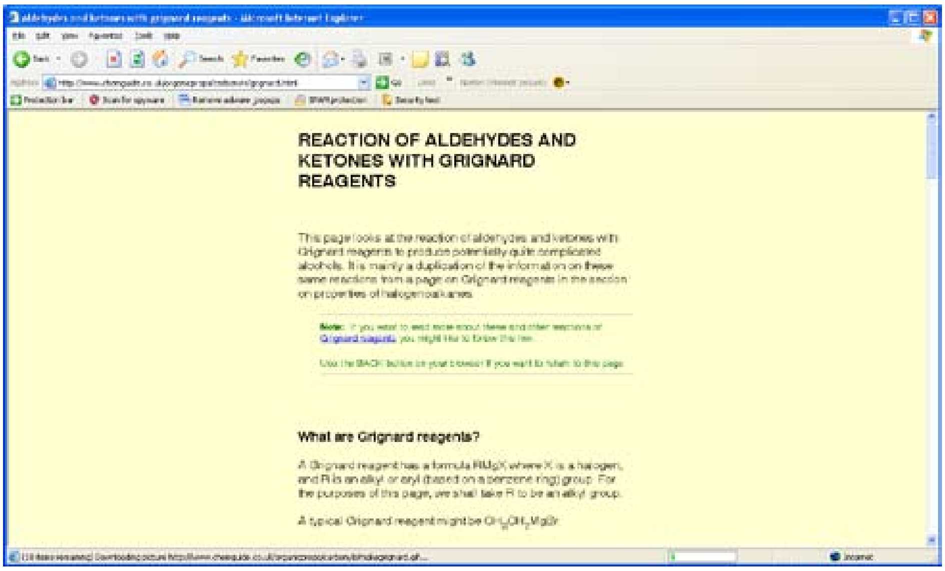
The net effect is that an oxygen atom from the oxidising agent removes a hydrogen from the -OH group of the alcohol and one from the carbon to which it is attached.

Useful Link 18

Title :Reactions of aldehydes ands ketones with Grignard reagents

URL: ***http://www.chemguide.co.uk/organicprops/carbonyls/grignard.html***

Screen Capture


aldehydes and ketones with grignard reagents - Microsoft Internet Explorer

REACTION OF ALDEHYDES AND KETONES WITH GRIGNARD REAGENTS

This page looks at the reaction of aldehydes and ketones with Grignard reagents to produce potentially quite complicated alcohols. It is mainly a duplication of the information on these same reactions from a page on Grignard reagents in the section on properties of halogenoalkanes.

Note: If you want to read more about these and other reactions of Grignard reagents, you might like to follow this link.

Use the BACK button on your browser if you want to return to this page.

What are Grignard reagents?

A Grignard reagent has a formula RMgX where X is a halogen, and R is an alkyl or aryl (based on a benzene ring) group. For the purposes of this page, we shall take R to be an alkyl group.

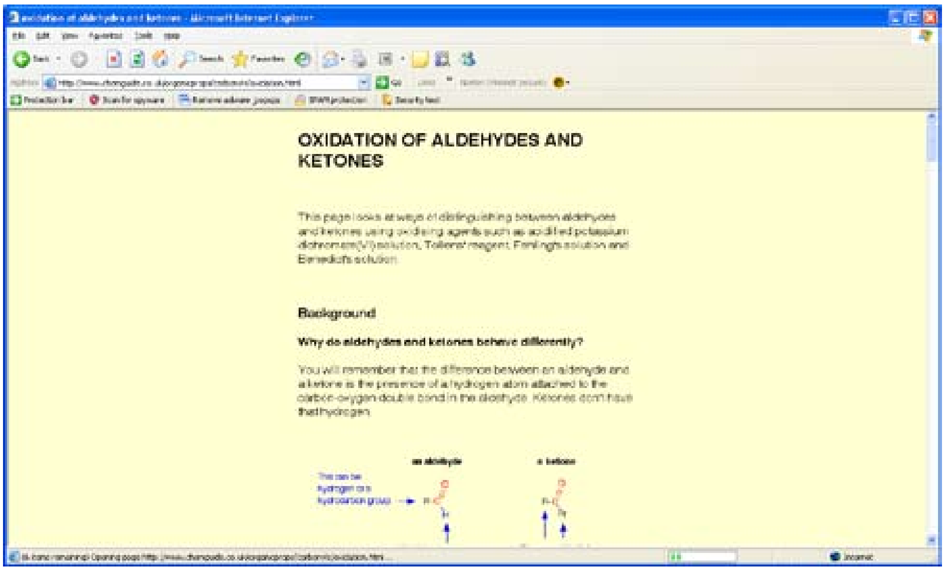
A typical Grignard reagent might be CH_3CH_2MgBr

Useful Link 19

Title : Oxidation of aldehydes and ketones

URL: ***http://www.chemguide.co.uk/organicprops/carbonyls/oxidation.html***

Screen Capture



OXIDATION OF ALDEHYDES AND KETONES

This page looks at ways of distinguishing between aldehydes and ketones using oxidising agents such as acidified potassium dichromate(VI) solution, Tollens' reagent, Fehling's solution and Benedict's solution.

Background

Why do aldehydes and ketones behave differently?

You will remember that the difference between an aldehyde and a ketone is the presence of a hydrogen atom attached to the carbon-oxygen double bond in the aldehyde. Ketones don't have that hydrogen.

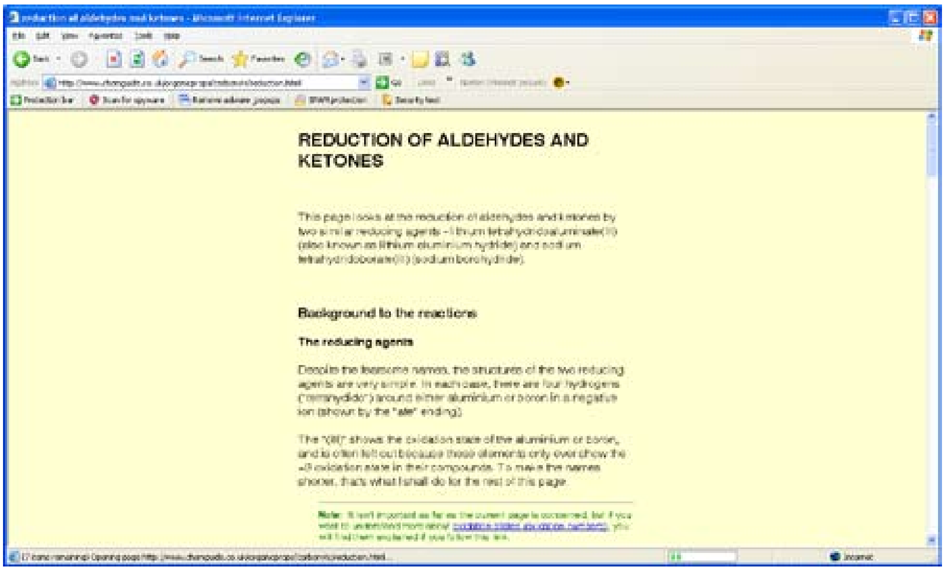
oxidation of aldehydes and ketones - Microsoft Internet Explorer
an aldehyde
a ketone
This can be hydrogen or a hydrocarbon group

Useful Link 20

Title : Reduction of aldehydes and ketones

URL: *http://www.chemguide.co.uk/organicprops/carbonyls/reduction.html*

Screen Capture



REDUCTION OF ALDEHYDES AND KETONES

This page looks at the reduction of aldehydes and ketones by two similar reducing agents - lithium tetrahydridoaluminate(III) (also known as lithium aluminium hydride) and sodium tetrahydridoborate(III) (sodium borohydride).

Background to the reactions

The reducing agents

Despite the fearsome names, the structures of the two reducing agents are very simple. In each case, there are four hydrogens ("tetrahydrido") around either aluminium or boron in a negative ion (shown by the "ate" ending).

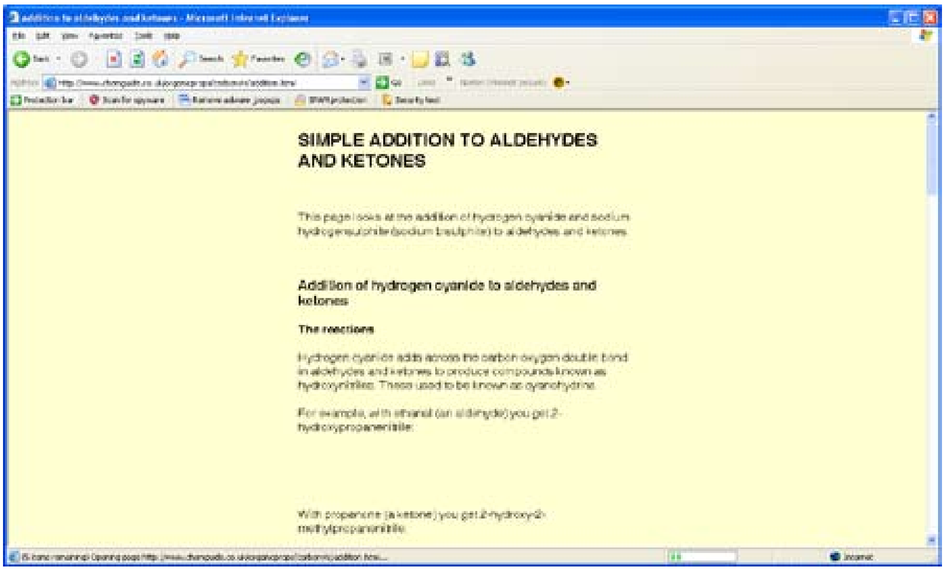
The "(III)" shows the oxidation state of the aluminium or boron, and is often left out because these elements only ever show the +3 oxidation state in their compounds. To make the names shorter, that's what I shall do for the rest of this page.

Useful Link 21

Title : Simple addition to aldehydes and ketones

URL: ***http://www.chemguide.co.uk/organicprops/carbonyls/addition.html***

Screen Capture



SIMPLE ADDITION TO ALDEHYDES AND KETONES

This page looks at the addition of hydrogen cyanide and sodium hydrogensulphite (sodium bisulphite) to aldehydes and ketones.

Addition of hydrogen cyanide to aldehydes and ketones

The reactions

Hydrogen cyanide adds across the carbon-oxygen double bond in aldehydes and ketones to produce compounds known as hydroxynitriles. These used to be known as cyanohydrins.

For example, with ethanal (an aldehyde) you get 2-hydroxypropanenitrile:

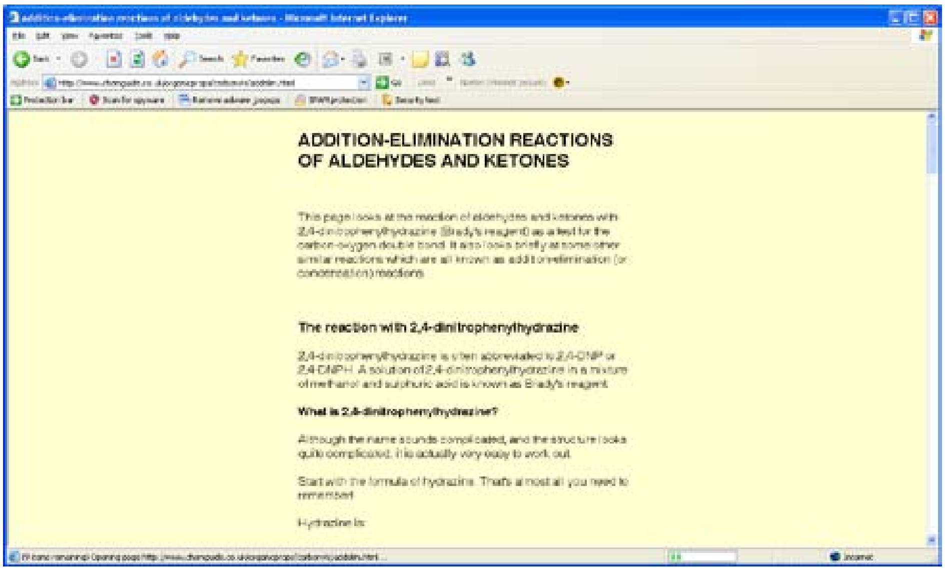
With propanone (a ketone) you get 2-hydroxy-2-methylpropanenitrile.

Useful Link 22

Title : Addition-elimination reactions of aldehydes and ketones

URL: *http://www.chemguide.co.uk/organicprops/carbonyls/addelim.html*

Screen Capture


addition-elimination reactions of aldehydes and ketones - Microsoft Internet Explorer

ADDITION-ELIMINATION REACTIONS OF ALDEHYDES AND KETONES

This page looks at the reaction of aldehydes and ketones with 2,4-dinitrophenylhydrazine (Brady's reagent) as a test for the carbon-oxygen double bond. It also looks briefly at some other similar reactions which are all known as addition-elimination (or condensation) reactions.

The reaction with 2,4-dinitrophenylhydrazine

2,4-dinitrophenylhydrazine is often abbreviated to 2,4-DNP or 2,4-DNPH. A solution of 2,4-dinitrophenylhydrazine in a mixture of methanol and sulphuric acid is known as Brady's reagent.

What is 2,4-dinitrophenylhydrazine?

Although the name sounds complicated, and the structure looks quite complicated, it is actually very easy to work out.

Start with the formula of hydrazine. That's almost all you need to remember!

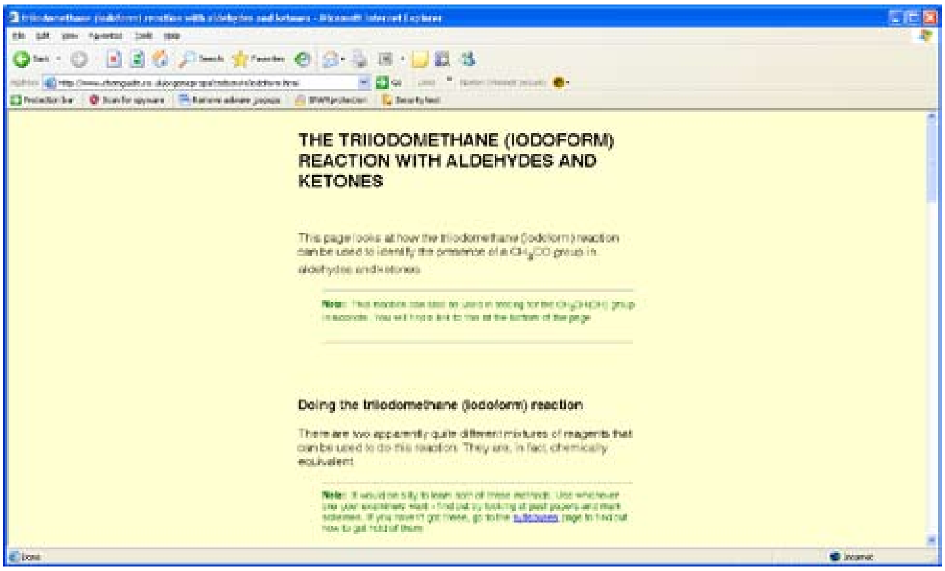
Hydrazine is:

Useful Link 23

Title : The triiodomethane (Iodoform) reaction *with aldehydes and ketones*

URL: http://www.chemguide.co.uk/organicprops/carbonyls/iodoform.html

Screen Capture



THE TRIIODOMETHANE (IODOFORM) REACTION WITH ALDEHYDES AND KETONES

This page looks at how the triiodomethane (iodoform) reaction can be used to identify the presence of a CH_3CO group in aldehydes and ketones.

Doing the triiodomethane (iodoform) reaction

There are two apparently quite different mixtures of reagents that can be used to do this reaction. They are, in fact, chemically equivalent.

XIV. Learning Activities

Learning activity # 1

Title of Learning Activity : Hydrocarbons

- understand the different types of hydrocarbons
- classification of physical and chemical properties of hydrocarbons

Summary of the learning activity : you will learn the following

Hydrocarbons : are the simplest type of organic compounds. Hydrocarbons are composed entirely of carbon and hydrogen atoms, and are widely used as fuels.

Gasoline, propane, and natural gas are common examples of hydrocarbons. Because they contain only carbon and hydrogen atoms, hydrocarbons are non-polar compounds.

Halogenation of hydrocarbons is the replacement of hydrogen by halogens particularly in alkenes and alkynes becaunce the alkanes are less reactive than the others.

Hydrogenation and halogenations reactions of both alkenes and alkynes to give alkanes and haloalkanes respectively

List of relevant readings

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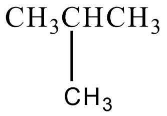
List of relevant useful links

Detailed description of the activity :hydrocarbons generally consist of three diffent groups called alkanes, alkenes and alkynes

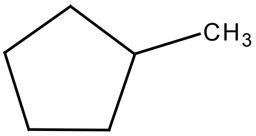
An alkane is a hydrocarbon that has only single bonds
An alkene is a compound that has at least one double dond.
An alkyne is a compound that has at least one triple bond.

Example of IUPAC nomenclature in naming alkanes and cycloalkanes



$CH_3\underset{\underset{CH_3}{|}}{C}HCH_3$

2-Methylpropane

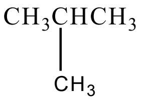


Methylcyclpentane

Naming hydrocarbons using the IUPAC system

Procedure:

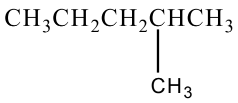
Step 1
Select as the parent structure the longest continuous chain, and then consider the compound to have been derived from this structure by replacement of hydrogen by various alkyl groups. For example, isobutane **A** (see below) can be considered to arise from propane by the replacement of a hydrogen atom by a methyl group, thus isobutane can be named as methylbutane



$CH_3\underset{\underset{CH_3}{|}}{C}HCH_3$

A

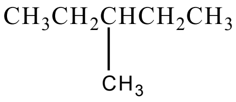
Methylpropane
Isobutane



$CH_3CH_2CH_2\underset{\underset{CH_3}{|}}{C}HCH_3$

B

2-Methylpentane



$CH_3CH_2\underset{\underset{CH_3}{|}}{C}HCH_2CH_3$

C

3-Methylpentane

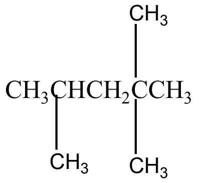
Step 2
ndicate, where necessary by a number the carbon to which the alkyl group is attached as is the case for the isomeric methylpentanes B and C above

Steps 3

In numbering the parent carbon chain, start at the end which will result in the use of lowest numbers; thus B above is called 2-methylpentane rather than 4-methylpentane

Step 4

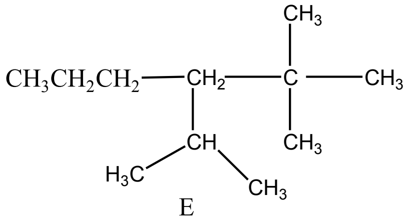
If the same alkyl group occurs more than once as a side chain, indicate this by the prefix *di-, tri-, tetra-,* etc to show how many groups of these there are, and indicate by various numbers the positions of each group, as in 2,2,4-trimethyl-pentane D



$CH_3CH(CH_3)CH_2C(CH_3)_2CH_3$

D

2,2,4-trimethylpentane



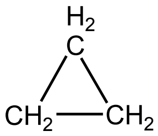
E

3,3-Diethyl-5-isopropyl-4-methyloctane

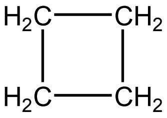
Step 5

If there are several different alkyl groups attached to the parent chain, name them in in order of increasing size or in alphabetical order; as in 3,3-Diethyl-5-isopropyl-4-methyloctane E above.

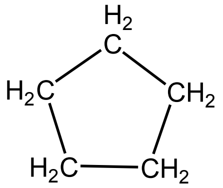
For cyclic system we use the prefix cyclo- to denote the cyclic naturefollowed by the corresponding open chain hydrocarbon name having the same number of carbons as the ring. For example:



cyclopropane

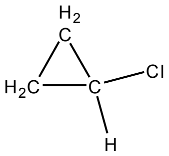


cyclobutane

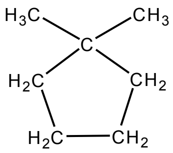


cyclopentane

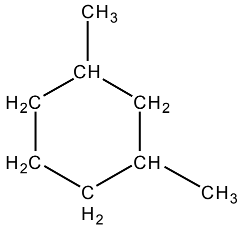
The position of substituents on the ring –alkyl groups, halogens, etc. are indicated by by numbers. We assign position 1 to a particular carbon and then as to number clockwise or otherwise around the ring so as to give the lowest combination of numbers. For example:



Chlorocyclopropane

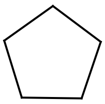


1,1-Dimethylcyclopentane

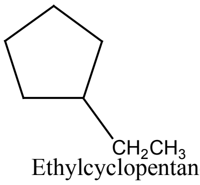


1,3-Dimethylcyclohexane

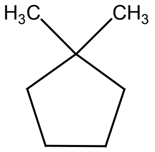
Cyclic aliphatic rings are normally, for convenience represented by simple geometric figures: a triangle for cyclopropane, a square for cyclobutane, a pentagon for cyclopentane and a hexagonon for cyclohexane and so on. It is understood that two hydrogens are located at each corner of the figure unless some other group is indicated. For excample:



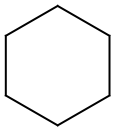
Cyclopentane



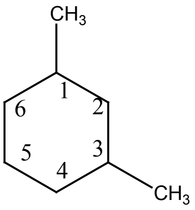
Ethylcyclopentane



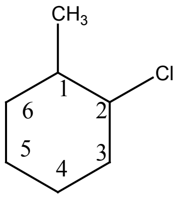
1,1-Dimethylcyclopentane



Cyclohexane



1,3-Dimethylcyclohexane



2-Chloro-1-methylcyclohexane

Formative evaluation

Name the flowing hydrocarbons

A) CH_2-CH_2- CH-CH_3

CH_3 CH_3

B) CH_2=CH-CH_3

Learning activities

Organic chemistry deals with virtually all carbon compounds.

Hydrocarbons: Carbon can form more compounds than any other element because carbon atoms are able to link up with each other in straight chains.

Hydrocarbones are made up of only two elements , hydrogen and Carbon. On the basis of structure , hydrocarbons are devided into two main classes –Aliphat and Aromatic.

Alphatic hydrocarbon: contain carbon atoms that are bonded in one or more chains and rings. Carbon atoms can have single, double or trible bonds. Aliphatic hyrocarbons include straight chain and cyclic alkanes,alkenes and alkynes.

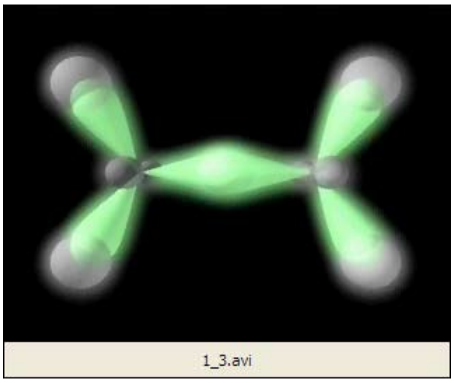
Aromatic Hydrocarbons: These are are benzene and other hydrocarbons that resemble benzene in their chemical behaviour

Benzene is the simplest aromatic compound. Its bonding arrengement results in special molecular stability.

An alkane is a hydrocarbon that has only single bonds. Alkanes that do not contain rings have the formula CnH2n+2. An alkane in the shape of a ring is called a cycloalkane. Cycloalkanes have the formula C_nH_{2n}.

An alkene is a compound that has at least one double dond. Straight-chain alkenes with one double bond have the same formula as cycloalkanes, C_nH_{2n}. A double bond involves two pairs of electrons. In a double bond, one pair of electrons forms a single bond and the other pair forms an additional, weaker bond. The electrons in the additional, weaker bond are more easily ccessible for reaction than the electrons in the single bond. Thus carbon-carbon double bonds are more reactive than carbon-cabon single bonds.

An alkyne is a compound that has at least one triple bond. A straight-chain alkyne with one triple bond has the formula C_nH_{2n-2}. Triple bonds are even more reactive than double bonds. The function group for an alkyne is the triple bond.



Learning activity # 2

Title of Learning Activity : Alcohols and Ethers

The student has to understand

- the functional group of alcohols and ethers
- various catagories of alcohols and ethers
- predict synthesis of alcohol and ethers

Summary of the learning activity

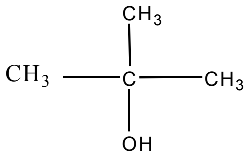
You you will learn the following

Alcohol : is an organic compound that contains the hydroxyl group –OH. An alcohol can be an primary,secondary and tertiary.

Ethers : organic compunds that have two alkyl groups joined by an oxygen atom. The general formula of an ether is R-O-R

Formative evaluation

Differentiate the three types of alcohols which one is the primary, secondary and tertiary alcohol?

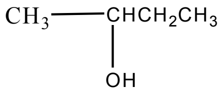


$CH_3-\underset{OH}{\overset{CH_3}{C}}-CH_3$

A

$CH_3CH_2CH_2CH_2OH$

B



$CH_3-\underset{OH}{C}HCH_2CH_3$

C

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List of relevant useful links

Detailed description of the activity :

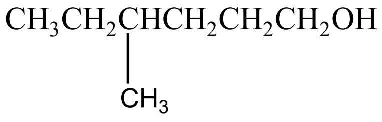
Alcohols : is an organic compound that contain the hydroxyl group –OH. An alcohols can be an primary,secondary and tertiary.

Ethers : is an organic compunds that has two alkyl groups joined by an oxygen atom. The general formula of an ether is R-O-R

Formative evaluation

Name the folliwing alcohol and ethe rusing the IUPAC system . Identify whether alchol is primary, socondary and tertiary

A



$CH_3CH_2\underset{\overset{|}{CH_3}}{C}HCH_2CH_2CH_2OH$

B $CH_3CH_2OCH_2CH_2CH_3$

A) CH2-CH2-CH3

I

OH-CH2-CH2-CH-CH3

B) CH3-CH2-O-CH2-CH2-CH3

Solution A

Step 1
the main chain has six carbon aoms. The name of parent alkane is hexane.

Step 2
Replacing –e with –ol gives hexanol.

Step 3
Add a position number for the –OH group, to obtain 1-hexanol.

Step 4
A methyl group is present at the fourth carbon. The prefix is 4-methyl.

Step 5
the full name is 4-methyl-1-hexanol. This is primary alcohol.

Solution B

Step 1
the longest alkyl group is based on the parent hydrocarbon propane.

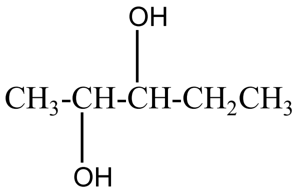
Step 2
the alkoxy group is based on ethane (the ethyl group) located at the first carbon atom of the propane part. Therefore, the prefix is 1-ethoxy-.

Step 3
the full name is 1-ethoxypropane.or ethyl propyl ether

Now name the flowing compounds

A. $CH_3CH_2CH_2OH$

B



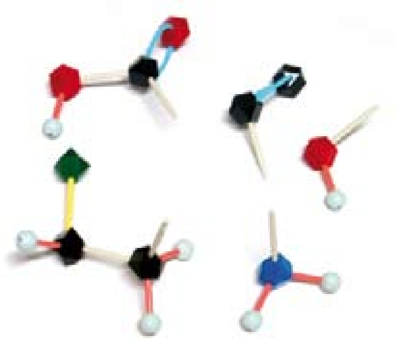
$CH_3\text{-}\underset{OH}{CH}\text{-}\overset{OH}{CH}\text{-}CH_2CH_3$

C $CH_3CH_2CH_2CH_2OCH_3$

Learning activities

Alcohols : is an organic compound that contain the hydroxyl group –OH. An alcohols can be an primary,secondary and tertiary.

Ethers : is an organic compunds that has two alkyl groups joined by an oxygen atom. The general formula of an ether is R-O-R



Learning activity # 3

Title of Learning Activity : Alkyl halides

We hope the student to learn

- halogenation of alkyl halides
- naming the alkyl halides
- physical and chemical properties of alkyl halides

Summary of the learning activity

You will learn the following

Alkyl halides: an alkane in which one or more hydrogen atoms have been replaced with halogen atoms such as F,Cl,Br or I.

Hologenation of hydrocarbons are replacement of hydrogen by hologens particularly alkenes and alkynes becounce the alkanes are less reactive than the others.

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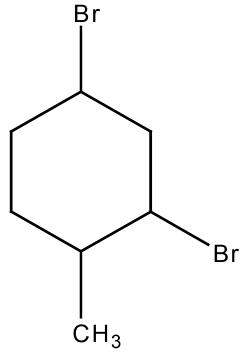
List of relevant useful links

Detailed description of the activity :

An alkyl halide may be considered as an alkane in which one or more hydrogen atoms have been replaced with halogen atoms

Halogenation of hydrocarbons are replacement of hydrogen by hologens particularly alkenes and alkynes because the alkanes are less reactive than the others.

Example of naming alkyl halides using the IUPAC nomenclature



Solution:

The parent hydrocarbon of this compound is cyclohexane. There are two bromine atoms attached at position numbers 1 and 3. therefore part of the prefix is 1,3-dibromo-. There is also a methyl group at the position number 4.

The full prefix is 1,3-dibromo-4-methyl.

The full name of the compound is

1,3-dibromo-4-methylcyclohexane

Formative evaluation

Draw structural diagram for each of the following alkyl halides.

A) bromoethane

B) 2,3,4-iodo-3-methylhebtane

Learning activity # 4

Title of Learning Activity : Amines

- different categories of amines
- the general structure of amines
- naming amines using IUPAC nomenclature

Summary of the learning activity

You will learn the following

Amines: an organc compound with the functional group –NH2, -NHR, or -NR2 is called an amine.

The letter N refers to the nitrogen atom. The letter R is refers to an alkyl group attached to the nitrogen. The general formula of an amine is therefore RNH2, R_2NH,or R_3N where R is an alkyl or aryl group.

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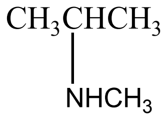
List of relevant useful links

Detailed description of the activity :

Amines: an organc compound with the functional group –NH2, -NHR, or NR2 is called an amine.

The letter N is refers to the nitrogen atom. The letter R is refers to an alkyl group attached to the nitrogen. The general formula of an amine is therefore $R\text{-}NH_2$, R_2NH, or R_3N.

Example: Naming amines using IUPAC system



$$\begin{array}{l} CH_3\underset{\displaystyle |\atop \displaystyle NHCH_3}{C}HCH_3 \end{array}$$

Solution

Step 1
the propyl group is the longest of the two hydrocarbon groups attached to the nitrogen atom. Therefore the parent alkane is propane.

Step 2
Replacing the –e of the parent hydrocarbon name by the –amine gives the propanamine. The position number of the functional group in the propane is 2.

Step 3
a methyl group is also attached to the nitrogen atom. The corresponding prefix is N-methyl.

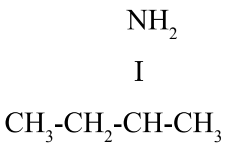
Step 4
The full name is N-methyl-2-propanamine.

Formative evaluation

Now name the following Amines

A)- $CH_3\text{-}NH_2$

B)-

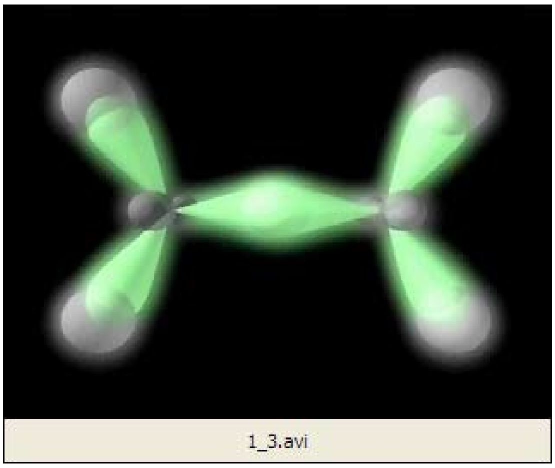


$$CH_3\text{-}CH_2\text{-}\overset{\displaystyle NH_2 \atop \displaystyle |}{CH}\text{-}CH_3$$

Learning activities

Amines: These are organic compounds whose functional group is –NH2, -NHR, or NR2..

The letter N is refers to the nitrogen atom. The letter R is refers to an alkyl or aryl group attached to the nitrogen.



1_3.avi

XV. Synthesis of the Module

This module is a starting course for the organic chemistry. It introduces the student to the chemistry of hydrocarbons: alkanes,alkenes and alkynes; the chemistry of alcohols; the chemistry of aldehydes and ketones; the chemistry of carboxylic acids

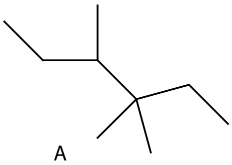
Therefore you must study it carefully before proceeding to other areas or courses. The given links are very useful for the module, make sure you consult most of them.

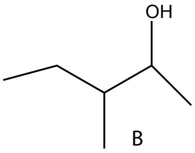
XVI. Summative Evaluation

Qn.1:

observe the following condensed structures (numbered1. to 8.) and match each each number with the letters A to L corresponding to the correct line structures given below: For example, if you think condensed structure numbered 3. Corresponds to line structure D then write your answer as 3 = D

1. $(CH_3)_3CCH_2CH(CH_3)C_2H_5$
2. $(CH_3)_2CHCHBrCH_2CH_3$
3. $CH_3CH(OH)CH(CH_3C_2H_5)$
4. $(C_2H_5)_2C{=}CHCHO$
5. $(CH_3)_2NCH_2CH{=}CH_2$
6. $CH_3(CH_2)_2CH(CH_3)CO_2H$
7. $CH_3CH_2CO_2CH(C_2H_5)_2$
8. $CH_3CHClCHClCOCH_2CN$


A



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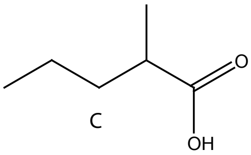

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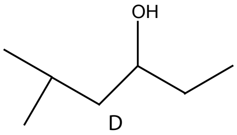

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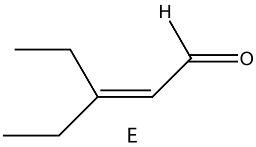

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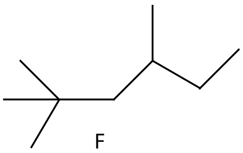
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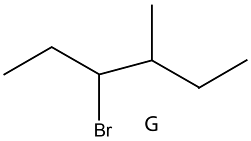

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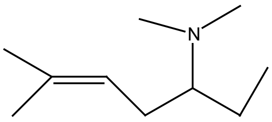

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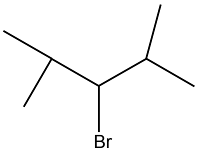

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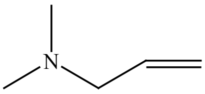

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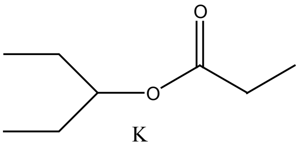

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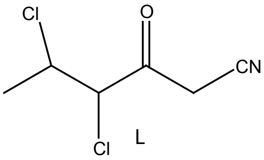
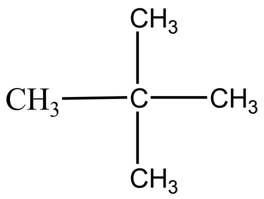


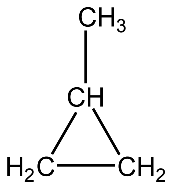
L

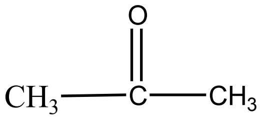
Qn. 2 :

Consider each pair of structural formulas a-d that follow below and choose the correct answer from the given answers A-C

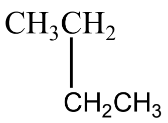
(a) 

$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-CH_3$ and $(CH_3)_3$-C-CH_3

(b) CH_2=$CHCH_2CH_3$ and 

(c) $CH_3OCH_2CH_3$ and 

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

(d) 

$\begin{array}{l} CH_3CH_2 \\ \quad\; | \\ \;\; CH_2CH_3 \end{array}$ and $CH_3CH_2CH_2CH_3$

Answers

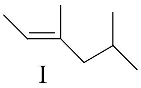
A. same compound

B. Different compounds that are constitutional isomers of each other

C. Different compounds that are not isomeric

Qn. 3 :

For each structure I-V assign the correct answer from those give (A to E)



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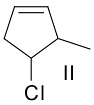
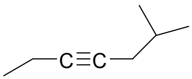
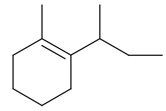


II



III



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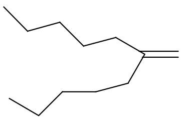

V

Possible Answers:

A - 2-Pentyl-1-heptene
or 2-Pentylhept-1-ene

B - 1-Methyl-2-(1-methylpropyl)cyclohexene

C - 6-Methyl-3-heptyne
or 6-Methylhept-3-yne

D- 4-Chloro-3-methylcyclopentene

E -3,5-Dimethyl-2-hexene
or 3,5-Dimethylhex-2-ene

Qn. 4 :

From a chemist point of view, which of the following answers is the best description of alcohols? Choose the most appropiate answer from the possible answers A-D below:

Possible answers

A. Compounds that can make people be drunk
B. compounds which have higher boiling points than hydrocarbons
C. compounds in which one or more hydrogen atoms in an alkane have been replaced by an -OH group
D. Compounds in which only one hydrogen atom in an alkane has been replaced by an –OH group

Qn.5:

In classifying alcohols which one of the following do we consider?

A. Their physical properties
B. the chain lengths
C. the carbon to which the functional group is attached
D. the taste of the alcohols

Qn. 6 :

The boiling point of an alcohol is always higher than that of an alkane of comparable chain length because of

A. interaction of the carbon atoms in the alcohol
B. van der waals forces operating in alcohol but not in alkanne
C. hydrogen bonding aperating in alcohol but not in alkane
D. ionic bonding in the polar alcohol molecules

Qn. 7 :

The solubility of alcohol in water is higher than in alkanes because

A. an alcohol is heavier than an alkane of the same carbon chain
B. covalent bonding in alcohol is better than in alkane
C. hydrogen bonging between the interacting molecules of the two compounds alcohol and water
D. ionic bonding between alcohol and water

Qn. 8 : The functional group in carboxylic acids is

A. a hydroxy group
B. both the hydroxyl and carbonyl group prhainesent in the molecule
C. carboxyl group
D. –COOH group

Qn. 9 : The boiling points of carboxylic acids are higher than those of alcohols of of comparable carbon chain due to

A. hydrogen bonding in carboxylic acids results in dimer formation
B. hydrogen bond interactions in carboxylic acids are less than in alcohols
C. dimer formation occurs also in alcohol but to a lesser extent
D. ionic interaction of carboxylic acids molecules to each other

Qn. 10 :

Amides and esters

A. are derivatives of both amines and acids
B. are both derivatives of carboxylic acids
C. both can be hydrolysed to give alcohols
D. both can be hydrolysed to give carboxylic acids

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